

INTRODUCTION

TO THE

SCIENCE OF THE PULSE.

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JULIUS RUCCO. M.D.

INTRODUCTION

TO THE

SCIENCE OF THE PULSE,

AS

APPLIED TO THE PRACTICE OF MEDICINE;

BY JULIUS RUCCO, M.D.

Of the Royal University of Naples, of the Royal College of Physicians in London, of the Medical College of Baltimore, and a Physician authorized by the ex-King of the Frenchmen, and by the King of the Belgians to practice the medicine in France, and in all the Kingdom of Belgium; Ex-professor of Anatomy and comparative Physiology in the Royal Medical and Surgical College of Naples, and Member of the Royal Institute of Encouragement in that Capital; Ordinary Member of the Medical Society of West-Minster, of the Royal Society of Jenner, at London, and of the Class of Natural Sciences in the Italian Academy of Sciences, Letters, and Arts; Corresponding Member of the Medical Society of Leghorn, of the Celtic Society of France, of the Academy of Natural Sciences, and of the Medical Society of Philadelphia; Author of various Medical Works, etc., etc.

NEW EDITION.



..... Me pulsus per integros duodecim annos medicinam facientem nunquam adhuc fefellit, sed sæpe tantum peperit mihi animi certitudinem, ut diem ipsamque horam mortis, ei soli confusus, sim ausus prædicere, et in illo quidem vix unquam temere, et in hoc vero non raro etiam eventum expectationi geminum habuerim.

SCHLHANNER.

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Lo Spirito della Sfigmica, o conoscenza del Polso applicata alla pratica medicina. 1 vol. in-8°. Napoli, 1810.

Recherches sur la prolongation de la vie humaine, etc. 1 vol. in-8°. Paris, 1812 et 1813.

Rapporti al Ministro dell' Interno di Napoli sull' amministrazione Economico-Medica degli Ospedali, degli Ospizii, e delle case di detenzione e correzione di Parigi. 1 vol. in-foglio. Napoli, 1814.

A Dissertation on the general principles of Anatomy and comparative Physiology. 1 vol. in-8°. Philadelphia, 1818.

L'Esprit de la Médecine ancienne et nouvelle comparées. 1 vol. in-8°. Paris, 1846.

*Letter of Sir HENRY HALFORD, President of the
Royal College of Physicians in London, to
Doctor RUCCO.*

Curzon Street. April 28, 1826.

“ SIR,

“ I return you the plan of your work which you have been so good as to permit me to read. It is comprehensive and good, and will be an useful work. I wish you every success in your undertaking, and assure you.

“ I am, Dear Sir, with esteem.”

Your faithful servant,

“ Signed, HENRY HALFORD.”

*Letter of Sir HENRY HALFORD, President of the
Royal College of Physicians in London, to
Doctor RUCCO.*

“ MY DEAR SIR,

“ I congratulate you on the near termination of the first volume of your elaborate work on the Science of the Pulse.

“ You have done me too much honour by dedicating it to me in such generous terms. I wish you, with all my heart, an ample reward for your diligence and

*

judgement in the execution of such a work, and shall always be with high esteem, my Dear Doctor Rucco."

" Your friend and faithful servant,

" *Signed*, HENRY HALFORD. "

June 27, 1827.

*Letter of Sir HENRY HALFORD, President of the
Royal College of Physicians in London, to
Doctor RUCCO.*

Triston-Hall, Leicester, August 6th. 1827.

" MY DEAR SIR,

" I congratulate you on the completion of your *useful work*, and most heartily wish you the just reward of your labours in abundant fame and whatever pecuniary advantages may fairly be expected from it.

" I shall not be in Town until about the 23th. of this month. If you are pleased therefore to send the remaining sheets to my house, my servant shall have a direction from me to transmit to me into the Country. With sincere regard and esteem, I remain, Dear Sir, yours very much. "

" *Signed*, HENRY HALFORD. "

*Letter of Sir HENRY HALFORD, President of the
Royal College of Physicians in London, to
Doctor RUCCO.*

“ MY DEAR DOCTOR RUCCO,

“ I most thank you with more than usual earnestness for your books. You have attired them beautifully and the whole work *is worthy of its author*. I wish you fame and fortune, and shall ever be with high esteem,

“ Your faithful friend,

“ *Signed, HENRY HALFORD.* ”

August 15th. 1827.

London, Weekly Review, No. xvll.

. “ We beg to call the attention of our Medical readers to Doctor Rucco’s very ingenious work on the Pulse. We think the profession ought to feel obliged to the author, for having bestowed so much attention and labour on a subject which, even among medical men, is too often not sufficiently attendet to; and for having placed before them in a connected form, all that is known on the subject. *This work deserves the attentive perusal of every professional man.*

Cambridge Chronicle, Dec. 14, 1827, No. 3, 399.

. . . “ Doctor Rucco, an Italian physician, who has resided some years in England, has lately published a very ingenious work on the Pulse. From the high encomiums which have been passed upon it by some of the most celebrated medical men in this Country and from the great attention and labour which the Doctor has bestowed on a subject of such importance, we think it deserves the attentive perusal of every professional man.

The New Literary Gazette, August 23, 1827.

. . . “ The truth, however is, that medical men, and even some of our best physiologists are lamentably ignorant of the nature of the Pulse; and we cannot do better than introduce Doctor Rucco's work by an extract in which he explains one of the most recondite processes of the human frame. . . .”

The Atlas, Sunday August 26, 1827.

. . . “ A single paragraph of Doctor Rucco's work on the Pulse, will show the medical and physiological acumen of its learned author.”

TO
SIR HENRY HALFORD, BART.,
K.C.H., F.R.S.,

PRESIDENT OF THE ROYAL COLLEGE OF PHYSICIANS,
AND ONE OF THE PHYSICIANS IN ORDINARY TO THE KING,

&c., &c.

SIR,

To that love for the medical science, which so eminently distinguishes you, and not to any merits of its own, is the present treatise indebted for the advantage of appearing under your dignified auspices.

May the same motives, Sir, which induce you to regard with a favourable eye all works except your own, actuate you in your judgment upon this feeble effort of one, whose highest reward will be to have merited your kindness, and to have shown himself not unworthy his place among that learned body, of which you are at once the head and the most distinguished ornament.

I remain, Sir,
with sentiments of profound
respect and gratitude,

Your obedient Servant,

*Golden Square,
1827.*

JULIUS RUCCO.

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PREFACE.

To know in what manner the author has been enabled to produce the present work, and to learn the favourable circumstances under which it originated, may prove neither devoid of instruction nor amusement to the reader; who, whilst he acquires, on the one hand, some information by perusing the account, therein given, of the means which have contributed to its production, may, on the other, receive some gratification, by observing the path which the author has traced out for himself, amid all the difficulties and lacunæ peculiar to the science of the Pulse. Lastly, the reasonings upon facts, which will be found succinctly propounded in the preface may, possibly, contribute to facilitate the labours of others desirous of undertaking the laudable task of perfecting this branch of science, if not, like the author, in a direct manner, at least indirectly, by

obeying the impulse of the same powerful motives, which determined him to commence his researches upon the subject of the present work.

Convinced that nature communicates with the physician, by means of the pulse, the author could not but be struck with the absurdity of the custom introduced and persisted in by the majority of practitioners, that, of making a momentary and slight examination of the pulse during a state of disease. He was therefore particularly anxious to abandon a practice as illfounded as irrational, and his researches, at length, demonstrated to him that, of which he had been long internally convinced; viz. that it is impossible for the physician to second or assist nature, when needful, if he refuse to listen to her voice, by neglecting to make a regular clinical examination of the patient's pulse; during which important enquiry, any distraction of the attention, either by talking or otherwise, is highly reprehensible.

The custom here alluded to, was also severely

and justly condemned by the learned FOUQUET, who, speaking with his usual candour of the little and bad use which most physicians of the last century made of the examination of the Pulse, thus expresses his surprise at the circumstance: “Il parait pourtant, et on ne le
 “ remarque pas sans surprise, que cette
 “ branche de l’art s’est fort peu accrue durant plusieurs siècles; l’exploration du pouls
 “ a été même long temps négligée, au point
 “ de n’être plus guère pour la plupart des
 “ médecins, qu’un manuel stérile en comparaison de la fécondité de cette opération
 “ bien étendue.”*

For the purpose therefore of introducing a rational reform into this branch of medicine, the author’s first care was to read and study the sphygmical works of SOLANO, BORDEU, FOUQUET, and CIRILLO; the perusal of which and similar treatises led him to devote his attention to the study of the pulse upon certain well defined and scientific principles,

* Fouquet, *Essai sur le pouls*, etc., page 11.

under a conviction that, in a medical point of view, the greatest advantages might be derived from it.

Although young, the author had at this period a considerable number of pupils attending his private lectures upon medicine, besides other students at the hospital of St. Giacomo at Naples, where he then (in 1804) exercised the functions of Regius Professor of Pathology: and whilst fulfilling both these important duties, he availed himself of every opportunity of investigating clinically, in the above mentioned hospital, the observations treated of by SOLANO, NIELL, BORDEU, FOUQUET and CIRILLO, observations which he investigated with the greater facility, as in his character of public and private professor, he had free ingress at all hours, and spared no trouble for the attainment of his object.

Thus favoured, he proposed uniting to the observations deduced from a long and deeply meditated examination of the Pulse, the results of a pathological investigation of the various kinds of diseases, the course and progress

of which he studied, noting the variations of the pulse usually produced by the action of different remedies, his object being to ascribe to their various causes the changes, upon which (according to the observations forming part of this work) the effects of those remedies have doubtless a reaction.

These and similar researches, connected with the state of the circulation of the blood, and consequently with the value, whatever it be, of the pulse, gradually led him to the results which he successively committed to his journal: and by thus proceeding from the known to the unknown, he at length succeeded in accustoming his mind and his tact to distinguish and discern, not only the difference between the various pulses which accompanied the different diseases of those admitted into the above mentioned hospital, but also the changes and variations, of which these same pulses were susceptible in the different periods of every hyperstenical and acute disorder. All which naturally concurred in facilitating the execution of the project he had already

meditated, of abandoning the absurd practice of examining the pulse in a merely formal manner, or of attending solely to the general ideas of Sphygmica, a science through which nature speaks to the physician by means of its organ the pulse.

Satisfied of the certainty of this truth, he continued for several years making new observations and researches. He availed himself of the intelligence of the age, and of his acquaintance with several celebrated and learned professors of the Royal University of Naples,* and by the assistance of these efficacious means accumulated fresh materials, which he added to the mass of information he had already acquired upon the subject of Sphygmica. Thus, like BORDEU, whose work upon the Pulse was, according to DUMAS, greatly indebted to

* MESSRS. Dolce, Cammajoli, Andria, Sementini, Petagna, Villari, Cotugno, &c. All these great luminaries of Naples have contributed to dissipate the thick darkness which obscured the horizon of medical knowledge, especially near the close of the last century.

the observations and learning of his masters and colleagues, all of the famous school of Montpellier, the author was enabled to collect the ideas derived by him from the above mentioned sources, and to concentrate them in a series of observations and theories; an undertaking which, but for these opportunities, he could never have accomplished, as he was then solely occupied with the care of increasing his stock of knowledge, the necessity of acquiring new facts being imperative.

Although, it was, at first, far from the author's intention to publish the results of his observations and researches upon the pulse, he afterwards considered, that without estimating too highly the services his work might render to Sphygmica, he might incur the charge of indolence, or of culpable indifference by exclusively confining its advantages to himself, and by allowing the suggestions of diffidence to interfere with the interests of his numerous pupils, already anxious for instruction in the principles of Sphygmica.

It was in this manner that the idea origi-

nated, of composing a course of lectures upon the Science of the Pulse, for the use of medical students, a favourable opportunity of reading which, soon presented itself in the Hospital Della Pace at Naples, with the further advantage of a simultaneous clinical examination of the pulses of patients ; and from the daily increasing number of students both medical and surgical, some idea may be formed of the impression made upon their minds, by the subject of the lectures.

Thus encouraged, the author renewed his efforts to overcome the scruples of diffidence, nor longer deferred publishing at Naples, in 1810, his elementary lectures, entitled *Lo spirito della Sfigmica applicata al trattamento delle febbri, ed alla doppia classe delle malattie*, the flattering reception of which work by his kind and learned fellow citizens, determined him not to forego his interests, by neglecting to improve it, as time and opportunity might permit.

By a royal decree, dated Oct. 9, 1811, the author, having been commissioned to proceed

to Paris, (a suitable pension being assigned him) for the purpose of prosecuting his medical researches in that capital, omitted no opportunity afforded him by so favourable an occurrence of improving his work upon the pulse.

Amongst other propitious circumstances from which he derived fresh materials, (thereby contributing to the improvement of his treatise) must be considered that of having received while at Paris, from the Neapolitan Government (by another royal decree of the 22nd of Dec. 1812) the honourable commission of investigating the institutions, laws, internal regulations and medical economy of the hospitals, poorhouses, and prisons of that capital. The official dispatch of Count Zurlo, then minister of the interior, a nobleman equally eminent for literary attainments and political sagacity, expressly required the author to notice particularly in his report, all the modifications and interesting circumstances connected with the rise and progress of those establishments. This task he performed to the best of his abilities, and the result of his labours may be

found among the public papers of the Secretary of State for the Interior, of the kingdom of Naples.*

This commission of investigating the hospitals belonging to the capital of France, was highly advantageous to the author's views, as in the performance of his duty, much of his time was engaged in repeating his enquiries into the pulses of many patients of every class, order, kind and species, those hospitals being generally very large and full of patients. It was here, he had an opportunity of observing some rare cases of organic and chronic diseases, accompanied by corresponding pulses; here he went into a fresh examination, not only of the critical pulses described by SOLANO, NIELL, BORDEU, and MICHEL, but also of the organic ones, treated of by FOUQUET, CIRILLO, and a few others; and, by comparing the critical and organic pulses of the Italians (of

* Rucco: Rapporti sul metodo economico-medico da praticarsi negli ospedali, negli ospizj civili e nelle case di correzione e detenzione. 1 vol. in fol. manoscritto. Napoli, 1814.

which he had a clear recollection) with those of the same kind among the French, he found in the striking comparison, not only the various changes and modifications exhibited by the same species of pulse, under the different circumstances of age and sex, but also the numerous variations arising from the nature of the different climates, and the physical character of the organization of their inhabitants.

The author was perfecting his sphygmical observations and researches, when the government recalled him to his native country in 1814; and, upon his arrival at Naples, after about four years' residence in Paris, a capital enriched with able surgeons, eminent physicians, and learned naturalists, presided at the opening of the royal college of medicine and surgery at Naples, and filled the chair of Anatomy and comparative Physiology; an honour to which he had been already promoted in 1813, agreeably to the royal decree of the 15th of July of the same year. Whether his public lectures were attended with that success which it was his ambition to deserve, must be

left to the decision of the impartial and enlightened public of that city.

He must however confess, that during this period, he neglected the further prosecution of his researches upon the pulse, a circumstance solely attributable to the attractions held out to him by anatomy and comparative physiology, sciences of which he at that time filled the chair, the arduous duties of which appointment, engrossed his whole time and attention.

The hope of being able to apply, with some degree of success, the information afforded by these sciences to the art of curing, suggested to the author the idea of extending his knowledge of practical medicine, by examining under every aspect, the different diseases incidental to the human body in various climates; an idea, which singular as it may appear, finally determined him to sail for the United States, towards the close of the year 1815; thus incurring all the disadvantages of a voluntary exile, rather than resist the impulse of a laudable wish to benefit science, or frustrate

the hope of rendering himself one day useful to the human race.

This was, if the author mistake not, another favourable circumstance, as it enabled him to interrogate nature, by observing the diseases indigenous to North America, diseases to the origin and symptomatic character of which, the excessive severity of the winters, and the not less intense heat of the summers contribute more than any other cause; the latter being the season in which the waters, after having overflown their banks, and inundated the circumjacent lands during the rainy days of spring, usually stagnate; a circumstance which added to the vast quantities of small animals, plants, &c. &c. in a state of decomposition, is frequently the cause of putrid and malignant fevers, and not rarely of the yellow fever itself, which usually predominates in the summer season, in consequence of the concurrence of these obviously pernicious and powerful causes.

An instance of this is found in the description given by FRACASTOR of the epidemy which devastated Italy in 1505 and 1528. In his

work, *De morbis contagiosis*, he attributes the putrid bilious fevers which occasioned such mortality there, to the continual blowing of the winds at noon, and to the incessant and heavy rains, which followed several inundations of the different rivers flowing through that country.

Nor must it be supposed, that the putrid bilious fever observed by FRACASTOR in Italy, was different, strictly speaking, from the yellow fever of America, not only, because both are characterized by the depravation of the vital powers, and the deterioration of the sensitive faculty, but also, because they both manifested themselves, by the external symptoms of nausea, and by the vomiting a bilious matter, more or less yellow, green, or black, “ C’est
“ encore sous la forme de fièvre bilieuse que
“ débute la fièvre jaune d’Amérique,” sagaciously observes the learned PINEL in his *Nosographia philosophica*.*

In furtherance of the object more particu-

* Tom. 1, page 59.

larly connected with his researches, the author's plan was to visit successively the principal hospitals of that vast continent, and more especially, to examine with the greatest attention, all that concerned the medical economy of the hospitals of New York and Philadelphia, where he could best observe and trace the effects of the Clinica generally adopted by the American faculty. The study of the physical character of the climate was his next care, whence he proceeded to investigate the customs, habits, and modes of living among the inhabitants; and having acquired these general notions, he went into the investigation of the diseases peculiar to the country.

For this purpose, the author determined upon exercising the medical profession in Philadelphia, a city more populous than the rest, and in which he established himself, as well on account of the ties of friendship which united him with several eminent physicians and professors, as of the many proofs of attachment he had received from numerous citizens to whom he had been previously introduced.

And, in truth, it will ever be a subject of congratulation with him, to have chosen that city for his residence, as independently of the great kindness of those friends, who will always be most dear to him, and in whose remembrance, he is ever anxious to hold a place, he had also a practice sufficiently extensive, to insure him the opportunity of studying, by the bed side of the patient, the genius, form, and character of the diseases most common to America; an advantage the more valuable, when we consider to what a degree, the old prejudice predominates in the United States, of regarding every stranger with a suspicious reserve; as if every European who arrived there, were deserving of such a reception; an idea, completely at variance with the intelligence of the age, and the progress of civilization.

So flattering an exception in his favour, will not allow him to omit this opportunity of paying a tribute of gratitude and esteem to his friends, the citizens of Philadelphia.

The same sentiments he is anxious to ex-

press towards those at Baltimore, especially to the learned Dr. Chatard, whose amiable qualities and distinguished talents have insured him universal respect and esteem: also, to the able chemist Mr. Ducatel, who, to a profound knowledge of chemistry and pharmacy, unites a refined taste for the study of Natural Philosophy.

As soon as the author found himself sufficiently introduced into medical practice, by the success which crowned the efforts of his zeal, he resumed his sphygmical researches, recalling to memory the results of his observations, and reading with serious attention his work upon the Pulse, a work which he may be said to have improved by great additions during his residence at Paris. This done, he confined himself to three kinds of researches. 1st. That of tracing the variations and modifications manifested by the diagnostic pulses in the diseases indigenous to North America, whether acute or chronic. 2ndly. That of observing the progress of critical pulses, among which the pectoral predomi-

nates, the pleurisy, pulmonia, and catarrh being three diseases of frequent occurrence in those countries. 3rdly. Enquiries relative to the gradations and modifications under which, organic pulses, in individuals living under the influence of different climates, present themselves to the touch.

Nor, while thus prosecuting his researches, did he neglect to compare in his mind, the homogeneous pulses of the natives of France and Italy, with those of Americans afflicted with similar disorders, so that he was enabled to discern and appreciate the variations, modifications, and differences which, under like circumstances, are produced upon the pulse, by the sole action of the different climates, influencing in various ways the physical constitution of man.

In other words, the author flatters himself to have derived much advantage from his scientific voyage, by observing among other important things in medicine, the variations, modifications, and differences which characterize the pulses of the inhabitants of

hot, cold, and temperate climates, whether they be in a healthy or diseased state.

Having thus accomplished the chief objects of his visit to America, by improving his work upon the Pulse and studying the medical topography of the United States; he next directed his attention towards London, with the view of repairing thither, for the purpose of the still further prosecution of his researches. He accordingly set sail from Philadelphia for England, and arrived in its metropolis on the 20th of June, 1820.

It will be obvious, that a mind thirsting after information, could not but be convinced of the great advantages accruing from the adoption of English models, in the prosecution of its researches and the completion of its labours, thus availing itself of all the improvements and discoveries which had already been made, and are daily making in the Hippocratic art by the learned faculty of the United Kingdom. And the reflection will ever be most gratifying to him, that he has had it in his power, to derive much valuable information

upon the subject of his researches, from the precious stores of knowledge with which HARVEY, SYDENHAM, HUNTER, CULLEN, JENNER, BROWN, DARWIN, BAILLIE, and many other eminent physicians have enriched their country.

The author candidly owns that no other motive has induced him to give this hasty sketch of his travels, and of the circumstances which have more or less contributed to the improvement of his work, than that of convincing his readers of the efficacy of the means employed by him for that object, assuring them, that if this his production be so fortunate as to obtain their approbation, it is to those circumstances alone, that his success can be attributed.

The author will hereafter explain the reasons, which induced him to treat upon a subject so complicated, extensive, and difficult, as Sphygmica must still be considered, notwithstanding the light it has received from SOLANO, NIELL, BORDEU, MICHEL, COX, FLEMING, and other classic writers. To confess a truth, their efforts have neither been so decided nor suc-

cessful as to clear the doctrine of the pulse from all the metaphysical subtleties and vices of the old school by which it is encumbered and deformed; and, candidly speaking, the author does not consider that their observations can serve as a guide to the physician practising in any country but the one in which those writers resided, an opinion which will appear the more correct, when it is considered that they wrote in an age comparatively barren, not only in anatomy and physiology, but also in every other branch of natural philosophy.

In fact, whatever may be the researches and observations made upon the pulse, and however numerous may be the patients, they are still in the author's opinion inadequate to the true object of *Sphygmica*, when uncombined with the principles of the general science of man, and when the patients, upon whom the experiments are made, all live under the same climate. The writer upon *Sphygmica* should, for many years, exercise his tact and reflection upon the pulses of numerous patients of hot, temperate, and cold climates; he

should take into consideration the differences in individuals of either sex, and of every constitution, age, and climate, not only in a healthy, but also in a diseased state; he should study the changes at the different periods of diseases, and above all, notice with accurate nicety the alterations which different climates produce under similar circumstances.

The author is moreover convinced, that a writer upon this subject, cannot describe the character of the various pulses which accompany the diseases indigenous to each climate, unless enabled so to do, by a favourable concurrence of circumstances: much less if he possess not the advantage of having resided and practised the medical art for some time in those climates.

But, notwithstanding his being seconded by the above favourable circumstances, and his having (as he candidly admits) availed himself of every observation both in ancient and modern writers, which appeared to him to bear upon his system; yet the author is conscious of having entered upon a most arduous and

difficult undertaking, not less a one, than that of sustaining upon his own feeble shoulders the ponderous weight of an immense colossal edifice, he being the first, who has endeavoured to lay the foundations of the sphygmical science upon the principles assigned it by anatomy, physiology, and practical medicine.

Of one thing however he is conscious, namely, that his efforts have been most sincere, in order to insure, at least, partial success; and this moral conviction of having done his duty, is dearer to him than any other recompense.

In conclusion, although the author should have failed in accomplishing the object of his persevering and anxious endeavours, he is not without the hope that the sketch, imperfect as it is, which he now submits with implicit confidence to the critical eye of competent judges, may at least serve to stimulate some other professor better qualified than himself to a similar undertaking. But, whatever may be the result of his labours, he feels persuaded, that henceforth his successors may supply the lacunæ, and overcome the difficulties which

have hitherto prevented the attaining a complete knowledge of the intimate relations and connexions which unite in one sole object, all the organs and functions of man. Then, when the hitherto mysterious phenomenon of life shall be less impenetrable, the attempts gradually to consolidate the foundations of Sphygmica (with the advancement of which the art of curing is so intimately connected) shall be found less arduous and difficult.

GENERAL IDEAS

UPON THE

SCIENCE OF THE PULSE.

I

AMONG other prevailing errors which have retarded the improvement and perfecting of the medical art, must be reckoned the use so general with practitioners, of considering Sphygmica as nothing but an obscure and mysterious science, a species of Chiromancy, &c. and of treating the study of it with indifference, nay, even with contempt: as if such an opinion were not grossly erroneous: as if Hippocrates and Galen, those two great luminaries of medicine had not set the highest value upon Sphygmica, nor been its most zealous promoters.

To this error, in the author's opinion, must be attributed the gradual decline of the doctrine of the pulse, from the elevated position in which it had been placed by Galen and others, to that low and neglected state in which it is at present found, to the disgrace of the progress which the human mind has al-

ready made, and is daily making towards perfecting the science of man.

The author is aware that at first sight *Sphygmica* presents numerous difficulties and lacunæ, the number of which must necessarily be encreased for those, who have not previously prepared their minds, by introductory studies, for the acquirement of a science, which although apparently abstract and metaphysical, is, in reality, founded upon experiment, of easy application, and of the greatest utility and importance.

Nor is it because practitioners usually confine themselves to a mere acquaintance with general pulses, that *Sphygmica* should therefore cease to be considered as capable of advancing the progress of pathology, of which it is properly a branch ; for (as will hereafter be seen) the diagnosis and prognosis, together with the treatment of various and different diseases, are all essentially connected with the state of the pulse : how great therefore, is the weakness of suffering one's self to be arrested by the mere sight of the difficulties, which, at the commencement, render the study of *Sphygmica* so formidable !

The misfortune is, that many practitioners cannot bring themselves to consider the cul-

tivation of it as interesting and important: anxious to spare themselves the tedium of the long and laborious researches, so indispensable for its acquirement, they willingly adopt the prevailing error, and maintain the disgraceful absurdity, that Sphygmica has no foundation whatever in physical certainty, that it is the mere offspring of the imagination, and that the idea of its utility is purely romantic. Vain subterfuge! Instead of insulting the name and reputation of Hippocrates and of Galen, by thus depreciating Sphygmica, which it is well known, they held in the highest esteem, instead of thus unjustly detracting from the merit of many other physicians, both ancient and modern, by contributing to undervalue their researches, the antagonists of Sphygmica ought rather to make themselves acquainted with the works of Solano, Nihell, Borden, Cox, Fouquet, and Cirillo, in which the fullest and most convincing proofs are to be found in favour of the doctrine here advocated, proofs which, while they compel them to retract their former erroneous opinion, will, at the same time, force them to acknowledge and appreciate the light which Sphygmica has diffused over the horizon of medical knowledge. “Il faudrait une prévention bien aveu-

“gle,” observes the worthy Fouquet “lors-
“qu’on a lu les excellentes choses sur le pouls,
“que nous ont données quelques modernes,
“pour pouvoir douter que cette doctrine ne
“soit infiniment avantageuse à la médecine,
“soit en la tirant de ce nuage défavorable des
“conjectures dans lequel ses plus ardens dé-
“tracteurs et les théories plus pernicieuses
“encore ne cessent de l’envelopper, soit en la
“simplifiant et en la ramenant à cet état de
“médecine narrative ou de faits, qu’ont pro-
“fessé Hippocrates et ses disciples, et à la-
“quelle le chancelier Bacon désirait si ardem-
“ment qu’on revînt de son tenis.”*

It is moreover with regret, that the author finds himself compelled to remark, that the medical writers of the present day, feel no inclination to follow the footsteps of their predecessors in the last century, by making *Sphygmica* a subject of disquisition in their classical works; an oversight, or rather a cold indifference, which not only diminishes the taste, so requisite for successfully prosecuting the study of that science, but likewise indirectly encourages its opponents, to represent it as useless, if not obscure and mysterious. With

* *Essai sur le pouls, page 21.*

the exception of the works of Buchoz,* Claye,† and Dr. Sachero,‡ to whom Sphygmica is indebted for the results of their valuable researches and observations, no others, to the author's knowledge, have as yet been published.

That but few writers are at present found to take up the subject of Sphygmica; that we see this branch of pathology slighted, neglected, and almost forgotten by the majority of practitioners, and finally, that it has not kept pace with its sister sciences, in its advancement towards perfection, the author ascribes to the manner in which it has hitherto been treated and reasoned upon. Besides which, all the treatises of ancient writers upon Sphygmica, smack of the metaphysic of the old school; nor, when we consider that all the auxiliary sciences were then in their cradle, can it be expected, that the ancient physicians could, in any sensible degree, contribute to the

* *L'art de connoître et de désigner le pouls par les notes de la musique. Paris, 1807.*

† *Observations sur le pouls, avec une méthode facile d'en reconnaître les différentes espèces. Paris, 1809.*

‡ *De pulsibus organicis, diagnosticis, et prognosticis, &c. Aug. Taurinorum, 1823.*

improvement of that science. The writings of Galen, Aëtius, Actuarius, Pietro Salio, Prospero Alpinus, Struzio, Zecchius, Baillou, Bellini, Boerhaave, Hoffmann, Solano, Nihell, Bordeu, Menuret, Gandini, Falconer, Rumball, and others, are all in the taste of the times in which they lived; those authors confined themselves to treat of some, not of all the branches of the sphygmical art; their works were published at a time when physiology was not, as at present, enlightened by new facts, and consequently, all wandered from the true object of the science, that of collecting all their observations into one body of doctrine, or regular system.

By regular system, the author means that which consists in the well ordered and harmonious disposition or arrangement of the different parts of any art or science whatsoever, in which all reciprocally support each other, and in which the last are explained and demonstrated by the help of the first; so that those parts which furnish the reasons of the rest, are called principles, and the system resulting from them, is the more solid and irrefragable in proportion to the simplicity of those principles.

Such, however, is not the character of any of

the works now extant upon Sphygmica, neither of those written in ancient times, in the middle ages, nor even in the last century; and although it may be advantageous to consult them occasionally, and our admiration be raised at the genius of their authors, whose merit it is to have accumulated a vast mass of facts and luminous observations, and of having afterwards added them to the stock of human knowledge, their works are not on that account, the less incompatible with the intelligence and taste of the present age.

For, (to produce an example of their imperfection) of what utility is the knowledge of the naked fact, that the critical Diarrhæa, is announced by a small, deep seated and intermittent pulse, when the mind has not a clear conception of all the ideas relative to the different parts of the sphygmical science; since, while it is thought that such a pulse, according to those authors, should foretell the critical Diarrhæa, it announces instead, the prostration of the vital powers, or the presence of an organic disease, in the ventricles, auricles, or in the large arteries, or else indicates the fatal termination of an acute disorder.

Nor can it be affirmed, without the risk of error, that the advantage of ascertaining the

cause which produces this or that pulse, or which constitutes it critical, organic, or symptomatic, can be obtained from simple observation unconnected with the principles of this science. Hundreds of examples might be adduced to prove the defects of these works, works which require to be corrected and improved by the information of the present age, thus placing them upon a level with the actual state of anatomy and the progress of physiology. The enlightened mind of Bichat enabled him to perceive this very deficiency, nor did he fail to point out the method to be pursued for the correction and improvement of this branch of medical science. “C’est un
“travail qui exige d’être entièrement refait” says Bichat, upon the subject of the motion of the blood, and of the pulse, “soit avec les
“matériaux qu’ont déjà ramassés une foule
“d’auteurs estimables, surtout Haller, Spal-
“lanzani, Weitbreck, Lamure, Jadelot, etc.,
“soit avec des faits nouveaux.”*

Although the few sphygmical works published in modern times appear conformable to the new facts and physiological improvements; they have, notwithstanding, certain defects and

* Bichat, Anat. gén. Tom. 2. p. 339.

deficiencies which can only be corrected and supplied by one, who unites reasoning with observation, and is deeply versed in the science of the pulse.

In the first place, it must be observed, that, in none of the modern works upon *Sphygmica*, is there a complete and correct examination of all the various modifications, which the natural pulse assumes in the different periods of life, in either sex, in different physical constitutions, in the varied modes of living, in the different climates, &c.; and even when this examination is found in any of these works, it is so rapidly and superficially gone into, that the information best calculated to elucidate the subject in question, still remains a desideratum.

Secondly; no mention is made in these works, of all the various effects produced upon the pulse, by the different remedies prescribed by physicians, in every civilized country; neither do they notice all the necessary information, respecting the material instrument of the pulse, as if the knowledge of its mechanism were different from that compass, which can and ought to direct the physician, in the midst of the vast and trackless ocean presented by *Sphygmica*.

Another error is the allowing novices in this

science, to go immediately into the examination of organic and critical pulses, before they have been made acquainted with their principles, or have stored their minds with simple ideas and new facts, capable of informing them upon the structure of the heart and arteries, and mechanism of their functions, and the compelling them to confine all their attention to observations alone; merely leads to the jargon and externals of the science. Not less necessary for them is the knowledge of the physiological state of the pulse, it being that which fixes the most certain standard, by which the changes, variations, and alterations of the pulse in a state of disease may be valued, calculated, and appreciated; and this standard or criterion which discovers the cause of every diagnosis, prognosis, and mode of treatment; this standard, balance, or criterion is to be exactly found in the examination of all the various modifications which the pulse assumes in a healthy state by means of whatever impairs, modifies, and changes the organization, structure or tissue of man's fibrous material, during the course of life.

The actual state of the science, therefore, does not allow the practitioner to come to the

study of organic and critical pulses, without the necessary requisite of being able to recall to mind, during the act of examining the pulse, all the variations and modifications which it assumes and manifests in a healthy state, for the purpose of comparing them (in every case) with the forms, changes, and alterations it undergoes during disease; for, it is only the comparison between the criterion of the natural pulses, and the one which forms the object of examination, that can determine, with any certainty, the character, value, or species of the pulse observed in the state of disease. In support of this reasoning may be adduced Bordeu's opinion, who says "Solano
" n'a rien dit de l'action des remèdes sur le
" pouls; il a omis de faire des remarques sur
" le pouls dans l'état de santé, remarques sans
" lesquelles on ne peut presque rien statuer
" sur le pouls dans l'état de maladie."*

The having recourse, as several physicians are accustomed to do, to an artificial standard, such as a watch, pulsilegium, or pendulum, as a substitute for the natural one, afforded by the exact knowledge of the physiological state of the pulse, is an irregular and fallacious practice,

* *Recherch. sur le pouls, pag. 259.*

for the evident reason, that by means of the former, it can only be ascertained how often the artery pulsates in one or more minutes, and whether the pulse be frequent or rare, quick or slow; but in no way can it be ascertained, if the pulse be strong or weak, great or small, hard or soft, equal or unequal, critical, organic, or symptomatic. The pulsilegium is a weight suspended from a thread, the frequency of whose oscillations is in proportion to the length of the thread. This pendulum, being set in motion, oscillates, and the number of its oscillations within a given time becomes, according to some physicians, the measure of the pulsations.

In different countries also of the old and new world, the custom obtains of examining the pulse, referring at the same time to a watch. Besides, however, the observer's attention being distracted, by following with his eye, the hands of the watch, and by counting the pulsations, this method cannot shew the character, value, or species of the pulse examined, although in this knowledge consist all the advantages to be derived from an examination of it. The pulsilegium, or watch, therefore, is made for such, as adopt the superficial and fallacious practice, of merely touching the

artery with the fingers, and not for those, who feel the necessity, of discovering the meaning of the expressions pronounced by nature, by means of its organ the pulse, as well in a healthy as a diseased state; the use therefore of the watch or pulsilegium, in the examination of the pulsations of the arteries, is altogether useless. Fouquet condemns it in the following manner, “On peut en conclure de l'estime due à ces sphygmomètres, et à toutes ces autres curiosités physiques dont les mécaniciens ont amusé pendant si long temps la médecine rationnelle, et dont il n'a pas tenu à eux d'embarasser encore la médecine pratique.”*

It is only in certain cases of fevers, and other febrile diseases of a malignant species, that the use of a watch may sometimes be tolerated, during an examination of the pulse, because the frequency or excessive quickness of the pulse, or indeed both, when they occur together, may give greater weight to the diagnosis and prognosis, and to their treatment, especially in old people affected with epidemic fevers, in whom, the frequency and quickness of the pulse, indicate the greatest degree of

* Op. cit. pag. 77.

fever, as their pulse is for the most part slow in a state of health, and consequently its increased velocity is of fatal import, during a state of disease.

Finally, in examining the sphygmical works published in the present day, it will be perceived, that their learned authors have not altogether renounced the old custom of paying more attention than they ought to the rules, formularies, external practice, and appearances of the pulse. As long, therefore, as it is not presented to the mind in the form of a science, nor directed by the light of theory, or by the guidance of its own principles, (whence proceed the results, which teach and generalize the utility of its practice) it will always appear as a neglected and inferior branch of pathology, instead of being considered, as the best cultivated and most esteemed part of practical medicine.

Observation is doubtless the source of medical knowledge, and the chief element of practical medicine: but the necessity of its being directed by a clear and enlightened logic, is equally true and obvious. Otherwise, how answer the question if proposed, as to what are the advantages and results derivable from the observations, which are, or may

be made upon different pulses, the various morbid phenomena, &c., when the mind does not undertake to investigate the causes in which they originate, and the mode by which they exist? And is not the study, or knowledge of their causes, that which leads to the logic of the facts upon which the true principles and elements of the science of Sphygmica may be the sooner established? Like those feeble lights which are extinguished by the first breath of wind, mere observations disappear entirely from the mind, and are in a short time completely obliterated and destroyed, when unsupported by one another, and not united by sound reasoning in a body of doctrine; the only method by which we can insure their permanency, and make use of them as necessity requires. Which caused Plato to remark, with the greatest justice, that learning is but a synonyme for recollection; and Senac, that theory determines experiment.

Now, how is it possible to imagine, that the mere practice, although long, of Sphygmica, which in its ultimate analysis proceeds solely from the application of observations, that such a practice can, without the light afforded by the logic of facts, and without

the guidance of the principles of the science, enable us to determine, when the changes and variations of the pulse arise from the cause of the disease, when they result from the reaction of certain symptoms, or when they originate in the sympathy of other diseases, in the healthy strength of nature, in the action of the remedies, or in the organic affections, as yet not well developped? Nor is it aught else than wandering amid thick obscurity and a confusion of ideas, to endeavour to search for, and to individualize the cause of every species of pulse, by the feeble light afforded by a practice destitute of all principle and theory, or which is tantamount, devoid of medical logic?

There are two most important points in the science of Sphygmica, the first is, that of uniting to practical observations the reasoning, which presupposes an acquaintance with their causes, and hence the obvious certainty of not confounding one species of pulse with another; the second, that of directing all information to a centre, not only that which is acquired at the bedside of a patient, in the sensible changes, in the progress of every serious disease, and in the variations and alterations of the pulse, which follow the course and the

event of it, but also the light diffused by pathological anatomy after death, which enables the acute mind of the well educated observer, to perceive the low and impaired state, to which the organic structure of the human body now lifeless, is reduced by the various disorders incidental to man.

Upon these two cardinal points, turns, at least the system, the method, or the law laid down by the author, in this work, as well to guard against the error of confounding one pulse with another, as of accomplishing his object of shewing their true cause, and thus smoothing the rugged and difficult path which leads to the diagnosis, prognosis, and treatment of the different disorders of the human race. If the author has not been successful in the execution of his plan, he nevertheless flatters himself and hopes, that he may awaken the zeal, and arouse the attention of many other experienced physicians, and induce them to perfect a work, of which the present treatise is but a slight and imperfect sketch.

May his feeble, but sincere and well meant efforts contribute once more, to shake off the mass of absurd opinions and prejudices, which tyrannize over the human mind, by attacking

the evidence in favour of the utility of the science of Sphygmica. May the means of recalling its ancient lustre to the recollection of our contemporaries, reproduce the study of it in our modern schools, and cause it ultimately to rise from that state of oblivion and contempt into which it has fallen! a wish, the accomplishment of which may be insured, by introducing into medicine the practice of shewing its value and importance, by means of observation, experiment, and reasoning. So fortunate an event, might, at least reinstate the doctrine of the pulse in that rank, to which it is entitled in the circle of medical knowledge.

Influenced by these considerations, the author concentrating his feeble powers, devoted himself to this useful, but peculiarly difficult undertaking. His first step was to arrange the materials collected by him from classic works of the highest authority, remodelling them according to the light thrown upon their subject matter by recent facts, and enriching them with the numerous observations made by him, both in the new and old world upon healthy and diseased subjects. His next care was to consolidate the results of his labours into the form of a scientific treatise; whether the author has or has not been successful, in

elevating the art of Sphygmica, by fixing its principles upon the solid bases of experiment and observation, and adapting the knowledge of them to the progress of the human mind, he leaves to the decision of the able and enlightened medical republic, with the full conviction, that if they do not realize his hopes, they will at least appreciate his feeble efforts.

That the science of Sphygmica has a favourable influence upon the art of curing, and is the guide of the medical practitioner by the bedside of the patient, admits not of a doubt; in proof of which it may be observed, that it is the nature of all fevers of a malignant kind to conceal their true character, that their symptoms often appear disguised, that the real cause of the disorders often lies hidden in the human frame, and that it is scarcely possible to conjecture the nature of the diathesis or morbose tendency. Now in these, and all similarly obscure cases of fevers disguised under false appearances, recourse must be had to the pulse, the oscillations of which sufficiently demonstrate the true state and condition of the vital powers, according to which the disease attacking receives its peculiar form.

One, among other proofs, which shews the difficulty of ascertaining and determining the

character of certain diseases, arises from the observation of fevers called *ardent*, the nature of which is the subject of various medical opinions. Some think that the ardent, is a variety of the gastric fever. Others consider it a species of the inflammatory one, while others, again, make it to depend upon a combination of both, as if produced by them. The same uncertainty still prevails among physicians, respecting epidemic and intermittent inflammatory fevers. Now, who does not see, how important it is in these cases, to consult the thermometer of the vital powers, namely, the pulse?

This organ, by means of its pulsations, is capable of shewing, not only the true state of the circulation of the blood, and of the other functions which contribute to, and depend upon it, but likewise, nearly the degree of the excitement and vitality, with which fevers of whatever kind, as well as the other various diseases of the human frame, are intimately connected: because they borrow from them the character, genius, and form with which they manifest themselves to the eye of the experienced physician.

The clinica also, which is exercised at the patient's bedside, cannot but always improve,

when the physician professing it, proceeds immediately to the motions of the pulse, in order to apply to clinica those observations, which render the exercise of it less difficult and more useful.

He, who does not interrogate nature by examining the pulse upon the principles of the art, runs the certain risk of committing two errors, the first, in attempting to distinguish the false from the true form of disease; the second, in prognosticating at hazard, that there is nothing to fear, when the disease is really serious, or that there is no hope, when the disorder is actually yielding up to the patient, his former good state of health, and in either case, the danger surely is not trifling, which involves the mistake of proscribing or rejecting remedies, when most required, or of administering them, when unnecessary. Now among other advantages belonging to the art of Sphygmica, must be reckoned that, of obviating, in a great measure, such serious errors, by consulting the state of the pulse, which likewise does not fail to point out, if any surgical operation be compatible or not with the patient's physical state, while from its strength or weakness, and from the peculiar mode in which it oscillates, may be discovered,

if pleurisy, or any other local or general inflammation be true or false.

From the state of the pulse may be ascertained, whether this or that crisis approaches to triumph over the disease, or to diminish still more the vital powers, and thus give the last blow to life; a circumstance not of rare occurrence in malignant fevers, which are unhappily, mostly followed by false and fatal crises; and it then becomes the more necessary to assist the one, and to oppose the other, by all the resources of art, as it is indispensable to snatch the patient's life from the menaces of immediate death.

To the true knowledge of the pulse corresponds, and is owing that self possession which experienced physicians evince at the bedside of the patient. These, in order to escape the snares often laid for them, by malignant fevers and by various other diseases, commence by attentively examining both pulses alternately, and, in many instances, the temporal or carotid arteries, an examination which they will repeat twice or three times in the same day; being, by this means enabled, not only to ward off the dangers with which their patients are threatened in acute disorders, but also to foresee the changes, and to pronounce with

much correctness their corresponding prognostics, upon the favourable or fatal termination of such disorders, which as is well known, are soon decided, by the skill or the inexperience of the medical attendant. Galen and many other eminent physicians notice in their works, the favourable termination, which justified the prognostics deduced by them from the true knowledge of the pulse.

It is this knowledge which is of great assistance to the physician, in his treatment of ataxic fevers, and of many other disorders of a malignant nature; all of which when compounded or complicated, are generally accompanied by symptoms fallacious, or in no degree regular or characteristic; it becomes, therefore, of the greatest consequence, not to act precipitately, and although the information afforded by pathological anatomy is useful in general, it will be better not to rely too much upon it in similar disorders, as these latter scarcely ever leave behind them any traces of organic injury, either in the structure of the organs themselves, or in their external tissue: in which cases, it becomes necessary, in order to ascertain the diagnosis, prognosis, and the remedy, to found all our judgment upon the state of the vital powers, which is deduced from that of the pulse.

The utility of the science of the pulse is also obvious, in the presence of the symptoms which the pulse alone indicates to the medical practitioner in the diseases of infants as yet unable to speak, of maniacs and idiots, as well as of many other patients, who, although possessed of speech and reason, are, from some cause or other, incapable of communicating their sensations and feelings to the physician. Such is the case of those afflicted with palsy, delirium, and lethargy. In some instances a blow or contusion will produce a physical derangement in the cerebral organ, which deprives the patient of the use of his limbs: in others, the stroke of apoplexy bereaves the unfortunate victim of the power of speech. Add to which, the relations of the sufferer (especially among the lower orders) are frequently incapable of being of any assistance, by furnishing information respecting the complaint.

Whence arises the necessity in these and other cases of like obscurity, of having recourse to the language of nature, that is to the examination of its representative, the pulse. Occasionally slow or quick, or alternately regular and irregular, the oscillations of the pulse must necessarily shew the state of the circulation of the blood, and of all

the other functions; for they all in turn contribute to the exercise of life, in as much as they are united by relations as close as they are mysterious; a truth which did not escape the sublime genius of Hippocrates, when he said; “*Confluxio una, conspiratio una, consentientia omnia,*”* nor the vast and fertile genius of Bichat, who thus expresses himself; “*Centre de toutes les fonctions, la circulation est toujours immédiatement liée à leur exercice; si elle est troublée, les autres languissent; elles cessent quand le sang est immobile,*”† How then after this can it be maintained, that the state of the circulation of the blood, which we obtain from the observation of the pulse, is not the index, thermometer, or manifest sign which indicates the state of the organs, and the condition of the functions of the healthy or diseased subjects?

Now, if the examination of the pulse, according to the established principle of *Sphygmica*, can be connected, even by approximation only, with the important object of ascertaining the true state of the organs and func-

* Hippocrat. *De alimentis*, pag. 162.

† Bichat. *Recherches physiol. sur la vie et la mort.* pag. 32.

tions of various patients, it would be difficult in this case, to say, why the oscillations of the pulse should be at variance with the expressions of nature; why, the moment in which the examination of the pulse takes place, should not be that, in which the physician can consult with nature; and, lastly, why the pulse should differ from the language of nature herself.

In support of this truth, I shall again quote the great physician Fouquet, who says, “ On y verra clairement que les plus fameux praticiens ont, de tout temps, regardé le pouls comme le véritable organe de la nature; que ceux même d’entr’eux, qui ont manqué là-dessus de connaissances approfondies, y ont soupçonné une expression importante que tout médecin légitime doit se piquer d’entendre, pour y subordonner ses démarches dans la cure des maladies.”*

But should the antagonists of Sphygmica affect to despise the arguments hitherto adduced in favour of this important branch of pathology, or, should fresh doubts prevent them from concurring with the author, in his opinion of its high value to medical science in

* Fouquet, *op. cit.* pag. 23.

general; they may yet derive some gratification by following, with unprejudiced minds, the author's exposition of this doctrine in the first and second volume of his work; convinced as he is, that, in endeavouring to establish his system, whatever may be its merit, upon solid foundations, and to strengthen it by unquestionable authorities, he has not advanced a single position incompatible with the laws of physiology and the maxims of the greatest physicians. His sole object throughout the work has been to make his labours and researches useful to the art of curing.

The more so, as this is no treatise of chiromancy, astrology, or magic, much less of the fabulous science of the Greeks, or of the enigmas and hieroglyphics of the Indians. The absurd prognostics of the Arabian doctors, and the senseless jargon of the Chinese physicians find no place here. All these artifices of quackery, ignorance, and avarice can no longer deceive, can no longer resist the light of science, and the advancement of general knowledge. Henceforth, the antiquated and absurd practice of examining the pulse, from mere formality, or of attending only to the observance of a few rules for the most part preposterous, is proscribed. It has also

been the author's object to precede the description of the various pulses, whether diagnostic, organic, or critical, by the simple ideas which are substitutes for principles, and thus by the assistance of sound reasoning, to combine the whole into one body of doctrine, applicable to the improvement of practical medicine, which, properly speaking, constitutes the subject of his researches.

THE

HISTORY OF SPHYGMICA.

IN the present sketch of the history of Sphygmica, the author's intention is to trace that science from its origin among the ancient inhabitants of the East down to the times of Solano, Nihell, Bordeu, Cox, Gandini, Fouquet, and Cirillo, after which it first commenced to decline; to describe its earliest form; to observe its different stages, particularly the progress it made in the time of Galen; to enumerate the eminent physicians both ancient and modern, who have cultivated it with the greatest success, and been its most sincere advocates; to deduce from their authority the favourable opinion which should be entertained of it; and lastly, by this brief account of its history, and by a comparison of its past with its present state, to prepare the reader's mind for forming an opinion how far the author's endeavours to promote the success of this interesting and useful art have kept pace with his intentions.

According to the most credible historians, the origin of Sphygmica remounts to the my-

thological ages, a period of time, comprehended, as is well known, between the creation of the world and the siege of Troy. Its history is precisely the same among all the orientals, by whom it was revered as the tutelary diety of the health of man. It was practised together with other superstitious customs by the Indian philosophers, who, for the cure of physical diseases depended solely upon their empirical knowledge of the pulse.

But while the Indian doctors examined the pulses of their patients with equal attention and affectation of mystery, they were not regardless of the changes which their features underwent; and for this they adduced as a reason, that every variation of the pulse must necessarily be accompanied by a corresponding alteration of the lineaments of the face, and that from these two kinds of observation, they were enabled to trace the diagnosis, prognosis, and treatment of different diseases.

While on the one hand the author agrees with the Indian doctors, as to the utility resulting from the ancient custom of attentively observing the connexion existing between the variations of the pulse, and those of the features, yet, on the other, he considers himself justified in disapproving of a simultaneous

examination of both, and for this reason, viz. that it is very difficult, if not altogether impossible, for the mind to employ at the same time the faculties of perception and attention, without weakening the strength of the one, and the intensity of the other. It would consequently be more compatible with the powers of the mind; first, to examine the pulse, and immediately afterwards, to observe the features by the help of a strong lens, by which means the medical practitioner having his attention undivided, would discover not only the changes in the features, apparent to common observers, but also those minute variations which are imperceptible to the naked eye.

The Chinese doctors were enthusiasts in, if not idolaters of Sphygmica; it appearing to them as a special gift of heaven, granted exclusively to a few superior minds; hence, the veneration with which that art has been treated both by antient and modern physicians throughout that vast empire.

Among the many other pretensions set up by the Chinese physicians, we will only remark (in this place) upon that, of being able to discover the cause, seat, and character of internal complaints by merely examining the pulse, and by observing (in a similar manner to

the Indian doctors) the eyes, tongue, and other features of their patients. As we proceed to treat on organical pulses, it will be seen how far the sphygmical knowledge of the Chinese extended.*

In Persia also medicine boasts a very ancient origin, and was held in the highest esteem; with this difference, that the Persian doctors practised the art of curing the sick, without examining the tongue, eyes, and other parts of the face, and judged of the nature of the complaint, either by examining the pulse, or, as was more common, by merely observing the urine. This practice arose from the custom still prevailing in Persia of keeping their women in a state of seclusion and concealment; scarcely are they allowed to present their arm to the doctor, nor is this ever done without its being previously covered with a veil, and passed through a curtain, which effectually conceals the patient.†

* For a complete account of all that is accurately known respecting the Chinese system, the reader is referred to the *Histoire des Chinois et des Japonnois*, etc.

† See *Voyage du Chevalier Chardin en Perse et autres lieux de l'Orient*. *Tom. v. ch. 15.*

Hippocrates, was, we believe, the first Greek physician who noticed the difference in the physical force of the arterial pulsations; this may be seen in his discourse upon sleep, angina, and diseases of females. Endowed as he was with a refined taste, which nature so rarely infuses into the human mind, Hippocrates saw, while yet young, and by the light of his vast genius, the inconsistency and absurdity of the medical dogmas then generally prevalent, dogmas, which had been almost consecrated by the authority of the highest antiquity; and having maturely reflected upon the plan he had conceived of freeing medicine from the metaphysical thralldom to which it had been subjected by the Indian, Egyptian, Chinese, and other oriental physicans, he finally succeeded in reforming almost the whole learning of his predecessors, and in overthrowing even to its foundations, the rude empiricism of *Æsculapius*; substituting in its place the present principles of the medical art, principles founded upon the firm basis of reason and observation. Such eminent success gained Hippocrates the honourable title of the Father of Physic, and raised his useful art to the dignity of a science.

From the above sketch, it must be evident

how much at variance with the profound knowledge of the venerable native of the isle of Cos, is the absurd although commonly received opinion, that the first observer and founder of rational medicine, did not cultivate the art of Sphygmica; an opinion opposed both by his discourse “*De somno, angina, et de morbis mulierum*,” and by the successful results of his prognostics, comprised in his invaluable treatise “*De prædictionibus*.”* Many other passages might also be adduced in evidence from his aphorisms, and from treatises in which Hippocrates himself affirms, that in the exercise of his art, he never omitted to observe the pulse very attentively in every disease, whether trifling or serious, simple or compound, acute or chronic; that, on the contrary, according to their different kinds, he was accustomed to notice alternately the pulsation of the radial, temporal, and carotid arteries, and not rarely the systole and diastole of the heart, applying his fingers to the external region of that vital organ;† that by the pulse, he could discover when his patients

* See de Mercy, Pronostics et Prorrhétiques d'Hipp.

† See his work “*De prænotionibus*.”

were affected by any violent passion ; that similar researches conducted him insensibly to the knowledge of various pulses connected with the different crises: in short, a slight acquaintance only with the invaluable works of that great physician, will suffice to convince the enquirer, that Hippocrates set a high value upon Sphygmica, and that, profound as it was, he did not disdain to cultivate the knowledge of it.*

In support of what is here advanced, may be quoted the authority of Bellini, a Florentine physician and celebrated anatomist of the seventeenth century, and of de Haën, a Dutch physician of the last, much esteemed among the learned, as the author of several excellent productions, especially of one entitled, “ *Ratio medendi in nosocomio practico*,” both of whom concur in assuring us that Hippocrates appreciated very highly the knowledge of the pulse. Such is also the opinion of Lefebvre de Villebrune, translator of Zimmerman’s valuable work upon experiment; of Dr. Serrurier, and many other distinguished physicians. According to Fouquet, Zanini likewise affirmed

* See his treatises *De lethargia, coac., et de morbis vulgar.*

that Hippocrates should be considered the first among those who had cultivated the art of Sphygmica.* Sprengel is therefore completely in error, as the learned Dr. Serrurier remarks, when he asserts that Hippocrates never availed himself of the indications afforded by the pulse,† an inconsistency into which Sprengel would never have fallen, had he reflected that Hippocrates, who reformed the medical theories of the Indian, Chinese, Egyptian, and other oriental physicians, among whom Sphygmica was held in the highest repute, could not have neglected the study of the pulse, it being in those times so principal a feature in the art of curing; on the contrary it is universally known, that the physicians of the remotest antiquity, pointed out the state of the arteries, and consequently that of the pulse in their description of various diseases, and it would be absurd to suppose that Hippocrates could set no value upon a similar practice.

That the knowledge of the pulse is of very ancient date, and that Hippocrates cultivated

* See Fouquet. *Op. cit.* p. 29.

† See Dictionnaire des sciences médicales. Tom. 44, p. 412.

the study of it, is further proved by the authority of Albert Haller, who, in tracing back the origin of Sphygmica, thus expresses himself, “ *Dignitatem vero nacta est, postquam medici, et in China, antiquissimis jam temporibus, et in Græcia signum morbi, et naturæ vires definiturum a pulsu repetere ceperunt. Hippocrates arteriarum pulsum non ignoravit, ad numeros tamen, adque subtiliora discrimina non est progressus.*”*

It may perhaps be objected that Hippocrates has at least not taken the trouble of tracing the prominent features of Sphygmica, since the little knowledge he had of it, and the few isolated observations he made upon it, cannot be considered as holding the rank of principles. To this it may be answered, that Hippocrates having lived five hundred years before Christ, a period so remote from that in which the discovery of the circulation of the blood was made, was precluded by his ignorance of that interesting fact from reducing his sphygmical knowledge to any fixed data. This effort of the human mind was reserved for a more advanced period, and depended upon the

* See Haller, elem. physiol. corpor. human. Lib. vi. Sect. 2. p. 243 & 4.

influence of new facts, and an acquaintance with the principles and laws by which the circulation of the blood and the other functions of the human system are governed.

For this discovery, as well as for much other valuable and useful information, we are indebted to the persevering labours and scientific researches of the immortal Harvey, an English physician of the seventeenth century.* Since, before the appearance of his most interesting work, “Upon the circulation of the blood,” which was published at Frankfort, in 1628; the other branches of medicine were unable to keep pace with the progress of anatomy and physiology, nor, but for that work, in conjunction with other fortunate events, (the offspring of time, circumstances, experi-

* According to the opinion of the learned and ingenious Dr. Baillie, and those of several other distinguished physiologists of Europe, the elements of the discovery of the circulation of the blood were prepared by Michele Serveto, Columbus, Cesalpino, and Fabricius of Acquapendente, professor of Anatomy in the University of Padua, under whom the celebrated Harvey studied, the latter being the first to demonstrate, with mathematical certainty, the truth of the doctrine. See Baillie's lectures and observations on medicine, *p.* 32, 35, 36, 38.

ment, and observation) could they have arrived at their present state of perfection. It was not therefore surprising that Hippocrates unacquainted as he was, with so essential a fact, as that of the circulation of the blood, should decline the bold and arduous attempt of establishing the foundations of Sphygmica; an attempt, which must have proved unsuccessful at so remote, and comparatively so ignorant a period; since which, as ages rolled on, the human mind has, sometimes by slow and laborious efforts, at others, as it were by inspiration, succeeded in surprising nature in the very entrails of the earth, in the distant planets, in the vast and unfathomable ocean, and in the vegetable and animal world. All the discoveries which have since exercised so powerful and happy an influence over the advancement of anatomy, physiology, and other natural sciences, and which constitute the brightest ornament of the age in which we live, lay, in the time of Hippocrates, concealed within the dark womb of nature.

The circumstance however of Hippocrates having lived in the time of obscurity and ignorance, and of having, for that very reason, been compelled to leave to another the arduous and difficult task of fixing the bases of the

sphygmical art, should not deprive him of the merit, of having advantageously applied the knowledge he had acquired and the observations he had made upon the pulse, to the art of prognosticating. In fact, who does not know, that even in the present day, his treatise "*De prædictionibus*," is considered as a masterpiece? Nor is it hazarding too much, by the assertion, that the sphygmical art, instead of making even a slow progress, as it certainly ought to have done in consequence of the observations of Hippocrates, was not only at a stand, but even retrograded till the time of Galen.

This opinion is founded upon the obviously blamable practice introduced into medicine almost immediately after Hippocrates, by his successors, of applying to the art of curing, one after the other, the philosophy of Democritus, Epicurus, and Aristotle; whence, the fashion which reigned in the schools of those days, of superseding reason and observation by the sophisms, hypotheses, and subtleties of the times, and hence arose in succession, the sects of the Methodici, Episentetici, Eclectici, Pneumatici, and Dogmatici, into which the medical successors of the venerable native of Cos, had divided themselves. Such were pre-

cisely the obstacles which opposed themselves to the advancement of the art of Sphygmica, as will be seen in the sequel of this history.

In fact, although, Praxagoras was the immediate successor of Hippocrates, and had in some measure followed the example of his predecessor, it cannot be said that he extended Sphygmica. Praxagoras, moreover, fell into the error of making so many divisions and subdivisions of the pulse, that, according to Galen, they formed a collection of obscure and unintelligible enigmas, rather than a body of learned observations; an error into which he was induced, by the taste which pervaded the schools of his day. Praxagoras introduced the innovation of ascertaining by means of the inequality of the pulse, the presence of diseases, and the alteration of the vital powers, as if neither of these could occur without the existence of the inequality of the pulse. Herophilus, who was the head of a sect, and a distinguished anatomist of his time, conceived the plan of uniting the chimerical principles of the Indian doctors with the general ideas of his predecessors, upon the pulse. Following the example of Hippocrates, he observed the variations, differences, strength and quickness

of the arterial pulsations, which he strangely assimilated to musical cadences; he remarked the changes of the pulse which obtain in different periods of life; described, in a very confused manner, the pulse which he calls *full*; but was more successful in his description of that by him designated *jumping*. He considered the power of the heart, which he made to depend upon the vital energy, as the cause of the arterial pulsations, and falsely concluded that the arteries are so many passive tubes. At all events, it does not appear that Herophilus had deduced from his researches relative to the pulse, the diagnosis and prognosis which have so justly immortalized the fame of Hippocrates.

Erasistratus also wandered from the right path, and fell into other errors. He was a distinguished disciple of Chrysippus, a celebrated anatomist of his day, and contemporary of Herophilus. The taste of these two eminent physicians for anatomy, was so decided, that they made several pressing applications to their government, for permission to dissect human subjects, and obtained it. Thus according to Celsus, and several other learned physicians it appears that both of them were authorized by their government to anatomize

the bodies of criminals, while living;* and that their object was that of exploring the viscera, for the purpose of observing their movements, and of seeking in the explanation of certain phenomena of living nature, (thus barbarously outraged,) fresh supports to the erroneous opinion, entertained by Erasistratus, that air, not blood circulates in the arteries and in the left ventricle of the heart. This was the reason, why Erasistratus attributed the cause of the arterial pulsations to the aereous spirit, which passing, as he said, from the pulmonary veins to the heart, and from the heart to the arteries, developped first in the former, and afterwards in the latter its elastic power, which was, according to him, the cause of the oscillations of both. From which it is obvious that Erasistratus devoted all his researches to the speculative part of Sphygmica; nor could it be otherwise, since he prosecuted them in the taste of the pneumatic school.

From the time of Herophilus and Erasistratus the state of the sphygmical art gradually declined; for Bacchius of Tanagra, their successor, making no difference between the

* See Baillie, *Op. cit.* pag. 12.

heart, arteries, and veins, asserted that the pulse might be observed and felt in all those parts, and that their pulsation was owing to the action of the blood. Zeno of Laodicea considered the heart as a continuation of the arteries, imagining the structure of all to be the same; he likewise confounded together the systole and diastole, believing as well, that both of them formed one action. And whilst Zeno makes the pulse to consist in the contractions and dilatations of the arteries, which, according to him, receive their power from the vital energy, he excludes altogether the influence of the heart.

Philalethes explains the mechanism of the pulse in two ways; in the first, he says, that the pulse is produced by the involuntary and sensible contraction and dilatation of the heart and arteries; and in the second, he attributes it both to the slight blow, which the continued and involuntary motion of the arteries gives the fingers, and to the suspension of that blow which immediately succeeds. Heraclides of Eritria, regards the pulse as an effect continually produced by the vital and animal energy, and makes it consist in a powerful contraction and dilatation of the heart and arteries. Aristossenes, on the contrary,

will not allow any influence of the vital and animal energy, as if in fact it did not exist, and circumscribes the exercise of the pulse to the sole functions of the heart and arteries, which, he says, possess that intrinsic power: many other ancient physicians, without defining in what the mechanism of the pulse consists, believed it to be a natural movement of the heart and arteries. In short, all these and many other successors of Hippocrates reduced the sphygmical art to a subject of dispute, and of metaphysical subtleties wholly incapable of improving its condition.

The sphygmical theory of Asclepiades, was not more reasonable, although, in his medical career, fifty years before the vulgar era, he had followed the track of experiment, and the guidance of sound reasoning: but, as he set out with false principles, it was impossible for him to arrive at the truth. In the first place, Asclepiades assimilated the human body to an assemblage of atoms, to the first and most subtle particles of which he attributed the vital powers and the pulse. In other words, he embraced the opinions of the pneumatic physicians upon the pulse, because like them, he supposed it was the aereous principle which occasioned the contraction of the heart and

arteries. Rufus an eminent physician and anatomist, who lived under the reign of Trajan, was a disciple of the pneumatic school. According to him, the heart is the receptacle of life and of animal heat, and is also the origin of the pulse, which he makes to depend upon the aereous spirit, passing from the heart into the arteries.

Agathinus of Sparta, although he had founded the sect of Eclectici, after having seceded from the pneumatic school; admitted, notwithstanding, pneuma into the arteries, without however believing that in a natural state such a stimulus could dilate the arteries to that degree as to make the pulsations perceptible; hence, in a healthy subjects, the observation of the pulse was useless. He affirmed that it was only when the pneuma acted with great elasticity and force, which was the case in a state of disease, that it could distend the arterial canals in any considerable degree, and consequently exhibit the full pulse. It is not surprising that Agathinus should have treated the pulse metaphysically, for that was the fashion of his day; what excites our wonder is, that he should never have given himself the trouble of ascertaining, whether the pulse did, or did not beat, in a state of health.

The first physician who introduced any thing like a beneficial change into sphygmica, was Archigenes, notwithstanding he was a follower of the Eclectici. His work upon the pulse was deserving of the commentary of Galen; and it is but justice to say, that the mode of observing the pulse is there pointed out, although imperfectly. In that work, Archigenes makes mention of the high, strong, and full pulse; of the quick and frequent pulse; of the regular and irregular pulse, and of the rhythmus; he there describes the violent, compressed, and irritated pulse; the long, wide, and deep pulse; the formicating pulse which he regarded as a bad sign, and the hard pulse, which he considered as a symptom calculated to indicate the presence of fever. Archigenes has at least, not been carried entirely away on the wings of his imagination, and has treated of the pulse with as much discernment as was compatible with the taste of his times. His contemporaries and successors, however, paid little or no attention to the changes he introduced into Sphygmica; as Cassius his successor, again referred the beating of the pulse to the pneuma, and affirmed that the alteration and celerity of the pulse in fevers is greater, in proportion as the aereous spirit becomes more rarefied,

subtle, and moveable, in consequence of the increase and concentration of the animal heat.

Amongst other followers of the fanciful pneumatic theory, were those who made the pulse to consist in the swelling and subsiding of the arteries, as if these latter were so many little puffs of wind.

Whence it may be concluded; that if some of Hippocrates' successors have introduced into Sphygmica, things of which that physician was not aware, or did not observe; they ought not the less to yield him the superiority, not only because he knew how to apply with consummate skill, his sphygmical observations to the improvement of practical medicine, a maxim not followed by any of his successors; but also, because no one has ever been able to prognosticate so successfully, the issue of various diseases, as the great Hippocrates.

From this rude and pedantic form, Sphygmica was at length partly rescued by the learned physician of Pergamus, I mean Claudius Galen, who lived in the second century of the vulgar era, and enriched the art in question, with many valuable observations. His first object was to clear away the mass of hypotheses, sophisms, and scholastic puerilities; his second, to establish principles, as little liable to fallacy, as was possible. The fact is,

that Galen had made such an advancement in the knowledge of the pulse, that in many instances, he gave proofs of his ability in prognosticating, which excited the surprise and wonder of his contemporaries. Thus, all the most eminent writers agree in saying, that Galen, prophesied like another Apollo, so well did he understand the art of the pulse. Haller attests this in his *physiologia*, when he observes in a note, “*Mirifica vero propriæ peritiæ in præsagio ex pulsibus exempla adducit.*” (*Galenus*).^{*} Fouquet also expresses himself in flattering terms upon Galen’s merit on the subject of the pulse: “*Les succès,*” says he, “*que Galien eut dans sa pratique, en s’éclairant des lumières du poulx, étonnèrent son siècle.*”[†] An opinion corroborated still more by the Sydenham of France, Dr. Pinel, who, treating upon the manner of studying and of making observations in medicine, in his classical work, entitled, “*Nosographie philosophique,*” passes the most handsome eulogium upon Galen, relatively to the same subject. “*Galien,*” he observes, “*s’étoit non-seulement rendu familier le traité du pro-*

^{*} Haller, *Op. cit.* lib. vi. *pag.* 244.

[†] Fouquet, *Op. cit.* *pag.* 30.

“ nostic d'Hippocrates, mais il en avoit étendu
 “ les règles par ses propres observations. Il
 “ annonce d'avance une hémorrhagie du nez
 “ critique, dans une circonstance éclatante et
 “ propre à lui donner une grande supériorité
 “ sur les autres médecins.”*

The following historical fact is conclusive as to the profound knowledge which Galen possessed, especially in Sphygmica. The two sons of the Emperor Marcus Aurelius had been entrusted to his care during their father's expedition into Germany. They were attacked with a malignant fever, and Galen, in the presence of several other learned physicians, prognosticated the favourable termination of the fever; his opinion was directly contrary to those of his colleagues; but the complete recovery of his two patients secured him a brilliant triumph, and effectually silenced his furious opponents. This and similar proofs of his great skill diffused his fame still more over every part of the civilized world. Thus Galen triumphed by means of what were accounted prodigies in his time, and rose superior to all contemporaneous physicians, in fame, glory, and desert.

* Pinel, *Op. cit.* Tom. i. p. 49.

Galen wrote an immense number of works, but those which treat of the pulse are considered as a masterpiece, although not free from the errors and vices prevailing in the schools of those times; I say, an immense number, because the greater part of his works served as fuel to the devouring flames which consumed the Temple of Peace, and only a few remains of his vast knowledge circulate in the libraries, or are treasured up in the minds of scientific physicians. In the fourth book of his works, we find the following treatises. *De pulsibus ad tirones*; *de pulsuum differentiis*; *de dignoscendis pulsibus*; *de causis pulsuum*; *de præsignatione ex pulsibus, et compendium pulsuum*. A more ample account of Galen's knowledge in Sphygmica or Sphygmology, may be found in Le Clerc's history of medicine. This learned historian gives a vivid and succinct account of all that Galen has written upon the pulse. Amongst other of his works he notices his book, "*De crisis*," and the other "*De prænotione*," in which Galen abandons his verbose logic, in order to attach and devote himself entirely to the observation and practice of pulses.

Galen's theory of the pulse is in fact of little or no value, and the mind soon becomes fatigued with the extravagance of his metaphy-

sical language: nor could he, after having imbibed his ideas from the pneumatic doctrine and the system of the Eclectici, disengage himself from the errors of those schools. It is the vital power, he says, which determines the oscillations of the heart, and it is the heart, in its turn, which communicates to the arteries, by means of the pneuma, the power of oscillating. Upon the whole, it cannot be doubted, that the physician of Pergamus far outshone his predecessors; that he had sensibly improved the condition of the sphygmical art; that he had at least established laws for it, calculated to advance its progress, and that his works which we have quoted, will be of the greatest utility to whomsoever wishes to devote himself earnestly, to the study of this important branch of pathology. But it cannot, on the other hand, be denied, that Galen himself has fallen into the error of multiplying the divisions and differences of the pulse, which, to say the truth, are not all admissible nor intelligible: and that he also indulges in many abstract ideas, and chimerical subtleties; a circumstance which induced Albert Haller to observe: “*Galenus eo majorem in hoc signo laborem posuit quod ab Hippocrate pene desertum videret. Divisiones vero, et classes adeo*

*subtiliter composuit, ut ad lectos aegri pulsum species difficiliter adgnoscas, quas separavit.”**

The rules laid down by Galen upon the pulse, served as a guide to the physician Aëtius. This learned man flourished in Alexandria, towards the close of the fifth century: almost all his treatises upon practical medicine and surgery were well received by the public, although Aëtius was indebted to Galen for the greater part of his ideas. The changes introduced by him may be reduced to those, of having brought into general practice the use of cautery, actual and potential, in cases of paralysis; of having circumscribed the efficacy of medicine to the application of magnetism, which he was the first to introduce, especially in the cure of the gout; and lastly, of being the author of several original and practical observations. With respect to Sphygmica, he made no alterations, as he followed the path traced out for him by Galen: his division of the pulse into external and internal, may be found described and pointed out in the third book of Galen's work upon crises. The happy results he gathered from his knowledge of the pulse led him to conclude, that it is by means

* Hall. Op. cit. lib. vi. pag. 244.

of the pulse, that the physician can distinguish the nature of different diseases, and prognosticate the event of organic affections.*

The political changes in Egypt, which was unfortunately subjugated by the Arabs soon after the close of the sixth century, arrested the progress which Sphygmicæ had begun to make under the auspices of Galen and Aëtius. Among the other acts of barbarism committed by the Arabs, with the intention of annihilating every trace of human learning, was that of committing to the flames the Alexandrian library, incontestably the richest and most celebrated of all extant at that time; and not satisfied, with this act of barbarism and grossest ignorance, if not of ill understood cunning, they still further testified their aversion for all learning and science, by overturning the famous medical school established in Alexandria; soon, however, repenting of so mad and barbarous a proceeding, they used every effort to collect together the remains of the Greek library, and instituted in Antioch, new public schools in which the Aristotelian philosophy was publicly taught.

Hence originated the transformation of

* See Aëtius, *De notis ex pulsibus*: Cap. xxvii. p. 195.

Sphygmica into a mere prophetical and delusive art. Under this form it was practised by the Arabian doctors. All their knowledge respecting the pulse was reduced to a few trifling theories, extracted from the obscure subtleties of the Eclectic school, and with these absurd and mysterious hypotheses the Arabian physicians began to predict future events, through the medium of the pulse. Some of these even boasted, that by observing the pulse, they could determine the quality of the food after it had been for some time introduced into the stomach. How valuable then, how important, is the establishment of public institutions, which, while they tend to promote the progress of civilization, prevent the abuses of quackery and empiricism! The glory of rulers and the dignity of nations are too nearly connected with such establishments for their utility not to be insisted upon.

The physicians who came after the demolition of the sphygmical edifice raised by Galen, made not the least advancement till Joannes Actuarius. Biancheli of Faenza, being imbued with the ideas of the Arabian doctors, who had metamorphosed Sphygmica into a prophetical and mysterious art, merely described the pulse, which he called *tortuosus*, that is, twisted like

a thread, and the *susalis*, by which he meant, elevated in the middle and compressed at the sides. This pedantic manner of speaking of the pulse, proves how far the sphygmical art had retrograded from the point to which it had been carried by Galen, and how incompatible its condition was with its real object.

It was Joannes Actuarius, a Greek by birth, who partly destroyed the scholastic opinions of the Arabs and their successors. Actuarius lived at Constantinople, in the thirteenth century, and is thought, with some probability, to have been the first writer who treated of mild cathartics. He extracted whatever was valuable from the remains of Galen's works upon the pulse, and by dint of fresh observations, arrived at the conclusion, that the doctrine of the pulse is capable of directing the physician as well in the task of foreseeing and distinguishing the various changes of the human body, as in forming a just idea of their value.* Actuarius therefore succeeded in withdrawing the attention of his contemporaries and successors from the erroneous principles of the Arabian doctors, and in fixing it upon the maxims and rules of Galen.

* See Actuarius, Quod post puls. urinar. aptant. ad prævid. Cap. i., pag. 115.

Pietro Salio, for whom Actuarius, his immediate predecessor, in some degree prepared the way, made numerous other observations upon the pulse, confirming practically all those of Actuarius. Convinced of the utility of the sphygmical art, he cultivated the study of it, and taking constantly the pulse as his guide, succeeded in predicting the termination of diseases, and in preventing their access. Salio in fact foretold to many patients that they would be attacked by syncope; this he did by merely observing the intermittency of the pulse; and very often succeeded in preventing a fresh attack by bleeding or other prompt and powerful remedies.* It was for this that Pietro Salio always set a very high value upon Sphygmica.

The practice of verifying the observations upon the pulse, by the bedside of the patient, became more general, and the taste of the old schools gradually declined: so that, Prospero Alpinus assisted by the information which he derived from the labours of his predecessors, succeeded in deducing many prognostics from the state of the pulse, all of which were fulfilled upon various occasions. Among others,

* See Freind, *historia medic.* pag. 161.

was realized the one which Alpinus made respecting a person afflicted with pleurisy, viz. that his disease would be cured by a copious discharge of urine. Alpinus, by birth a Venetian, lived in the sixteenth century, and was a celebrated physician and botanist of his time. After obtaining a doctor's degree at Padua, he sailed for Egypt, where he made a complete study of the plants and diseases indigenous to the country, as well as of the modes of cure adopted by the native physicians. Upon his return to Padua from Egypt, he acquired the general esteem to which he was justly intitled as well by his forcible writings as by his profound skill in medicine. His natural taste for, and attachment to the science of the pulse raised him to the rank of a great physician, and proofs of the wonders which he operated in the exercise of practical medicine are to be found in his work, entitled, "*De præsagienda vita et morte ægrotantium.*"*

Paul Zecchius, an eminent physician and learned professor of the celebrated university of Bologna, was no less attached to the study of the pulse, than Alpinus. After having increased by his own contributions the mass of

* See Op. cit. pag. 241.

sphygmical knowledge collected by his predecessors, he asserted that the doctrine of the pulse is the fundamental basis of the medical science, a basis upon which he, in fact, founded his classical work of practical medicine.*

Sthrutius, a physician of Padua, likewise distinguished himself in the knowledge of the pulse, and produced several observations upon this subject, worthy of a profound physician. He justly boasts, in his work "*De arte sphygmica*," of having acquired both fame and riches by taking the pulse for his guide in the treatment of various diseases. In fact, this work above cited, is, even in the present day, well worthy of being consulted and read, with the certainty of obtaining from it both profit and instruction. Haller himself gives the following favourable opinion of Sthrutius' work; "*Inter nuperiores medicos justo libro de pulsu Sthrutius egit.*"†

A similar taste for the study of the pulse inspired Baillou, who maintained that all the other branches of medicine were of little utility when the professor did not unite to them the knowledge of the pulse, by the assistance of

* See Zecchius de pulsibus, pag. 145.

† Haller. Op. cit. lib. vi. p. 244.

which the different diseases might more easily be distinguished, their changes foreseen and their termination prognosticated. He proposed the studying of different pulses, the comparing them together in the various periods of life, and the applying the results of these researches to practical medicine.*

A decisive argument in favour of the sphygmical art, is to be found in the observation made by Wierus upon the intermittent critical pulse. The substance of this observation consists in distinguishing the intermittent symptomatic pulse, (which generally announces death to the patient suffering under acute diseases) from the intermittent critical pulse, which points out to the attentive physician the means to be employed, in order to ward off the threatened danger, whether by purgatives, or any other remedy, which may successfully contend with and overcome the cause of disease: he also remarks, that in similar cases, there is not wanting a certain movement, which nature produces in the internal organs, for the purpose of preparing the necessary crisis.†

* See Baillou. *Epid. et Ephem.* Lib. ii. vol. i.

† See J. Horstius. *Cont. var. miscell.* Tom. ii.

Lorenzo Bellini likewise enriched the sphygmical art with many new observations, and cultivated the study of it with an industry equal to that of any of his predecessors. He defends Hippocrates against those who have thought, that this eminent Greek physician paid no attention to the variations of the pulse, at the bedside of the patient; and unfolds the practical knowledge and information which is to be found in his invaluable work "*De pulsibus.*" De Haën also undertakes the defence of Hippocrates upon similar grounds, for which purpose, he quotes from the numerous works of that great master, many passages proving the very reverse of what has been asserted by his unjust detractors.

Schelhammer made additions equally great and valuable to the collection of practical observations upon the pulse, and still further improved its condition. Amongst other of Schelhammer's flattering testimonials in favour of the doctrine of the pulse, it is gratifying to remark the one, which he brings forward with all the ingenuity of his mind in his dissertation;

lib. xi. in which will be found reported the luminous observation of Wierus upon the intermittent critical pulse.

there he assures us, that he was ever an enthusiastic admirer of Sphygmica, and that it served him as an unerring guide in all his judgments in the exercise of practical medicine.*

The author must here be allowed to observe, that he considers it to have been indispensably necessary to the object of his work, to prove by the authority of the most eminent physicians of antiquity, the utility and importance of the sphygmical art; pointing out at the same time the most remarkable changes which it has undergone. This he has accomplished in the present historical sketch, commencing with the first Indian doctors, and concluding with the physicians who lived in the last century.

By this sketch it will be seen, that among the Indian doctors the sphygmical art was from the first wholly obscure and mysterious; that it was the offspring of the creative genius of Hippocrates; that till the time of Galen its development was prevented by the metaphysical subtleties of the old schools; that it recovered its pristine vigour, and made fresh advancement by means of the profound re-

* See Schelhammer. Disquisit. Epistol.

searches of the second Hippocrates; that its developement and progress were again obstructed by the errors and fanaticism of the Arabian doctors, and lastly, that from the time of John Actuarius till Solano, it made no considerable progress. But the sphygmical art may however boast of two advantages, up to the time of the latter physician, the one is, that the faculty became much more convinced of its utility in medicine, and the other, that this opinion was founded upon the truth of certain rules which corresponded with their observations; observations which have therefore been applied with more success to the uses of practical medicine by the most illustrious physicians of the last century.

Among the number of writers of the last century may be reckoned Herman Boerhaave, a Dutch physician. He it was who endeavoured to bring into general use, the practice, then little understood, of examining the faces of diseased persons: it was he who partly reformed the humoral medicine of Galen, and maintained his reform for more than fifty years throughout the whole of learned Europe. To this he united the advantages of being professor of the celebrated

university of Leyden ; of possessing the spirit of observation ; of being profoundly learned, and of enjoying what he has so justly entitled to, the reputation of an eminent professor, a learned writer, and a man exemplary for modesty and moderation. After this slight sketch of Boerhaave's character and attainments, it will be satisfactory to observe the opinion he manifests in favour of the doctrine of the pulse, which he regards as a torch lighting the medical practitioner along the intricate and rugged path which conducts to the diagnosis, the prognosis, and the cure of physical diseases ; an opinion proving also the extensive use he so judiciously made of the information afforded by the pulse, in the exercise of practical medicine.*

Frederic Hoffmann also demonstrates by powerful arguments in his dissertation, "*De rationali pulsuum examine*," of what importance to the practice of medicine is the application of the knowledge of the pulse ; and that he had turned it to good account. It would therefore be most strange, if, in the face of such authority, and contrary to the

* See Boerhaave, in the 970th number of his institutions.

opinion of so many eminent physicians, the utility of the sphygmical art should still be called in question. But it must not be supposed, that because these medical writers have proved the great value of this art, that they have advanced this branch of pathology in any sensible degree.

This glory was reserved for Francis Solano, a Spanish physician. A mere glance over his classical work, "*Lapis Lydius Apollinis*," will be sufficient to convince the reader that Solano had sensibly improved the condition of the art of Sphygmica by his discoveries, and by the observations relative to the predictions which his knowledge of the pulse enabled him to make. "Solano," observes Fouquet, "fut
" le premier, au commencement de ce siècle, à
" qui la nature dévoila ses secrets, qui n'é-
" taient pas même probables pour les mé-
" decins de son temps."* The origin of his discoveries was the having exercised himself in certain states of the pulse, which were accompanied and followed by certain determinate critical evacuations. According to Don Roche another Spanish writer, Solano's work above mentioned appeared

* See Fouquet. Op. cit. p. 11 & 12.

in 1718. All the eminent physicians of the last century have acknowledged the merit of Solano's discoveries, and all have paid him a tribute of esteem and gratitude and among others Albert Haller, who thus expresses himself, "*Novas species earumque specierum significationes detexit Franciscus Solano de Luques, in Lapide Lydio Apollinis, cujus compendium edidit Jacobus Nihell. Inciduum inprimis pulsum primus definivit.*"*

This valuable book fell, according to Haller, into the hands of James Nihell, an Irish physician, who improved it by notes, illustrations, and additions: an example followed by Noortwick, who translated it into the Latin language; enlarged it in like manner with many learned reflexions, and published it at Amsterdam in 1746. Lavirotte, a physician of the medical faculty of Montpellier, made a French translation of it in 1748, which was published in Paris. Many other learned physicians employed themselves in a similar manner, and all began to examine by the bedside of their patients, the discoveries of Solano; and the result established their truth.

One among other physicians who were in-

* Haller. Op. cit. Tom. ii. p. 244.

tent upon this kind of researches was John Senac. He caused several soldiers who were diseased to be placed in a room by themselves in the hospital of Brussels, and there, took the opportunity of investigating not only the double pulse, called by some *Bis-feriens*, and by the French, *Rebondissant*, which warned him of the approach of hemorrhage; but also the intermittent pulse which announced the coming on of the abdominal flux. "The pulse," says Senac, "has been, and always will be the guide of the true physician; nor can those be undeserving of blame, who wish to depreciate that which instructs them respecting the seat, and the cause of diseases, the dangers accruing from them, and the resources of nature."*

Gerard Van-Swieten had a similar opinion of the utility of the knowledge of the pulse: whilst he exhorted his young pupils to fix their attention upon the study of Sphygmica, which he considered of the utmost importance to the improvement of practical medicine, he was not himself the less indefatigable in his search after the nature (oftentimes concealed and

* See Senac, dissertation sur les crises, also his traité du cœur, Tom. ii. p. 210.

masked) of certain diseases, always following the pulse as his guide in the treatment of them; and it was thus he was enabled to make such valuable additions to this branch of medicine.*

Another celebrated physician who was anxious to verify the discoveries and observations of Solano, by a practical examination of the pulse at the patient's bedside was the celebrated Theophilus de Bordeu. He did not however confine himself to a mere investigation of Salano's improvements, but entered upon a new kind of researches, and thus had the advantage of increasing still more the numerous discoveries of the Spanish genius. He added to them the produce of his own curious, useful, and profound observations comprised in his classical work, entitled, "*Recherches sur le pouls par rapport aux crises.*" Haller, speaking of this work, passes a high encomium upon its author in these words: "*Longe ultra Solanum progressus nuperus auctor.*"† Bordeu published his researches, at Paris, in 1758, and from that time, the number of physicians, who following his example devoted all their atten-

* See the fourth vol. of his Commentaries.

† Haller. Op. cit. lib. vi. p. 244.

tion to the knowledge of the pulse, increased more and more. Borden, it is true, diffused fresh lustre over the sphygmical art; but it cannot be denied, that he himself, like so many of his predecessors, fell into various metaphysical subtleties. His error, was that of making several abstract divisions and distinctions respecting the pulse, which cannot be borne out in practice. His learned fellow countryman, Dr. Pinel, advances a similar opinion upon the subtleness of certain distinctions, which are to be found in Borden's researches, "L'ambition," says Pinel, "d'enrichir par de nouvelles découvertes ce qui avait déjà été fait sur le pouls, n'a-t-elle pas fait établir à Borden des distinctions quelquefois subtiles, pour ne pas dire imaginaires? *

Following the track of the worthy Borden, Dr. Michel commenced new researches upon the pulse, confirming by fresh observations the doctrine of the author of the researches; this may be seen in his work entitled, "*Nouvelles observations sur le pouls par rapport aux crises.*"

At the time that Theophilus de Borden was

* See Pinel. Nosograph. philosoph. Tom. i. p. lxxx.

making his researches and observations at the hospital *De la Charite* in Paris, Cox and Fleming, both of them distinguished physicians and members of the Royal College of Physicians of London, were pursuing with ardent zeal, their labours upon the same subject. The former published in London several observations upon the intermittent critical pulse, which points out the utility of purgatives; and the latter wrote and published, in like manner, a learned dissertation upon the discoveries of Solano, concerning the modifications of the pulse, and the prognostics which can be deduced from them. Shortly afterwards many other classical works upon the pulse, appeared in upper and lower Italy, and in Germany: in short, the whole horizon of Europe was successively enlightened by the discoveries of Solano.

The learned Joseph Menuret also enriched the Encyclopedia with a long and diffuse article upon the pulse; in which, after noticing the sphygmical systems of the Chinese, of Herophilus, and Galen, he proceeds to develop with great genius and discernment the various objects forming parts of it. All his observations and reflexions bear the stamp of

correct judgment and profound learning, and at the same time give greater importance to the knowledge of the pulse.

It is to the certain and extensive influence which Sphygmica exercises over the progress of pathology and practical medicine, that we are doubtless indebted for the learned observations upon the pulse, made by the great reformer of physiology, Albert Haller, a native of Bern. His invaluable treatise upon the pulse, which may be found abridged in his classical physiological work is a convincing proof of the vast sphygmical knowledge acquired by Haller, by dint of observation and research.

Another celebrated physician who has shed a new lustre over the art of Sphygmica is certainly Henry Fouquet. The efficacious information which Fouquet gathered from the discoveries of Solano, from the illustrations of Nihell, the improvements of Borden, and the observations and reflexions of Menuret, suggested to his fertile mind the beautiful and sublime idea of studying the progress of the pulse in the presence of organic affections, and to his great surprise and astonishment this continued and profound study, led him to the discovery of the characteristics which dis-

tinguish organic pulses ; namely, those which discover to the touch the existence of internal local affections. It was in 1767, that Fouquet, after many years' researches, gave to the public his truly invaluable tractate upon the pulse of the principal organic affections, of which we shall speak more at length in the treatise upon organic pulses.*

The conclusion of the history of Sphygmica may be referred to the time of Domenic Cirillo, an eminent physician, and professor in the Royal University of Naples. In addition to the advantages derived from his labours by botany and practical medicine ; it was he, who towards the close of the last century, shewed the importance of the doctrine of the pulse to medicine ; he extended its practice by his celebrated treatise "*De pulsibus*;" improved its condition by pruning it of the greater part of the metaphysical subtleties, the remains of the old schools ; and applied its information, discoveries, and advancement to clinica.

From the account of the facts relative to the knowledge of the pulse, which the most

* See Fouquet. Essai sur le pouls par rapport aux affections des principaux organes.

celebrated physicians have described in their works, and from the combining of which has resulted the foregoing history of Sphygmica, tracing that art from the first Indian Doctors, to the latest European physicians, who have treated of it; from this account, I repeat, it does not appear that the actual state of the sphygmical art is that of a regular system. Its condition rather resembles that of a compilation of multiplied observations, united together with more or less elegance, but not so interwoven and combined as reciprocally to explain each other. Some of these observations regard critical pulses reproduced, confirmed, and better indicated by Solano, while others are relative to the organic pulses, if not created, at least placed in a new light by Fouquet: but neither of these eminent writers has undertaken to give them a regular form, nor to dispose them in such an order as that they might constitute a branch of science properly so called. This omission has arisen from the then rude state of anatomy, physiology, and the other natural sciences. The present day, therefore, in which the observations and discoveries of our predecessors, can receive such support and improvement from the progress of the science of man, was best

adapted, for disposing the whole of the materials in a body of doctrine, which should preserve them united in one regular and lucid system, at the same time that they should all concur in one sole object. Such was the friendly assistance of which the art of Sphygmica stood too much in need, to prevent its losing even a place in the circle of medical knowledge.

GENERAL PRINCIPLES
OF THE
SCIENCE OF THE PULSE,
SUCCESSIVELY DEVELOPPED IN
THE FOLLOWING ARTICLES.

HAVING, in the preceding historical sketch, traced the origin and various vicissitudes of the art of Sphygmica; it becomes indispensably necessary ere we cross the threshold of the science, to say something of the material instrument of the pulse: not only is it requisite to fix, for the present, the reader's attention upon the structure, functions, and physico-vital powers of the heart and arteries, in which, properly speaking, the phenomenon of the pulse takes place, but it will be also expedient to apply to this branch of medicine, the precept of Bacon, Descartes, and Condillac, and proceed from those simple and obvious ideas which are the substitutes for principles, to those compound, complicate, and abstract subjects, which depend upon and result from them.

And, whilst it may be considered at least an innocent, if not a useful task to recall to the

memory of the learned and scientific professor the general ideas, observations and most recent facts, which are best calculated to inform the mind upon the necessary connexion between the circulation of the blood and the mechanism of the pulse ; such a recapitulation will also have the advantage of enabling the reader who is but little versed in the science of physiology to understand the author as he proceeds in his subject : it moreover belongs to, and forms part of the plan of this work to bring into one point of view all the relations which unite together, in the human machine, the circulation of the blood with the other functions, in the exercise of which the great phenomenon of life still lies concealed.

Anatomico-physiological description of the Heart and Arteries, which constitute the material Instrument of the Pulse.

ART. I.

OF THE HEART.

ANATOMISTS designate by the word heart that hollow fibrous organ which is found protected by the pericardium in the centre of the cavity of the thorax, and which is placed upon the

diaphragm, between the two lobes of the lungs, exactly in the convenient space afforded it by the two laminae of the mediastinum.

Various are the opinions which have hitherto divided anatomists respecting the figure and external conformation of the heart. Some have given it the form of a reversed pyramid; others, that of a regular cone, whilst a third class have preferred comparing it to an irregular cone, produced by segments not perfectly circular.

But, whatever may be the external conformation of the heart; it is certain, that the irregularity of its form admirably corresponds with the intention of nature, of uniting in an organ thus formed, strength, durability, and freedom of motion. Destitute, as the heart is in the cavity of the thorax, of all fixed adhesion to any of the harder parts of the body, it necessarily required a figure under which it could develop and exercise its own strong, energetic, and free motions.

That the heart has no fixed adhesion to any hard part of the body will be clear from the following description. Upon opening the thorax, as is done in an anatomical dissection, this organ is seen placed obliquely from right to left, in the centre, as before observed, of the cavity of the thorax: its base being placed on

the right of the bodies of the dorsal vertebræ, and its apex, obliquely to the sixth rib on the left side; so that the left ventricle of which we shall hereafter speak, is almost posterior, and the right one, anterior. Its base and apex have in fact no adherence to any thing, neither the former, to the bodies of the dorsal vertebræ, nor the latter, to the ribs of the left side. It lies upon the diaphragm with its inferior surface flat, while its superior one which is convex, is united to the arterial and venous vessels, which keep it suspended in the centre of the thorax.

The heart is not however always found thus placed in a direction from right to left, nor even invariably in the cavity of the thorax. Dumas gives an account of the heart being found, in some subjects, parallel with the vertebral column; in others it was situated from left to right, so that in the living subjects, its beating would be felt upon the right side of the thorax; in others it was discovered placed in the cavity of the abdomen,* which caused Haller to say, "*Cor-dis pulsus non eodem semper loco percipitur.*† Bichat has been an ocular witness

* See Dumas, Princip. de Physiolog. Tom. ii. p. 313.

† Haller, Op. cit. Lib. vi. pag. 246.

to several mal-positions of the heart. Amongst other bodies which he dissected was that of a child, who had survived for more than a year the complete misplacement of his viscera: for, in the right side of the body, the French anatomist found the stomach, the spleen, the *S* of the colon, the apex of the heart, the aorta and the lung, composed of two lobes; and in the left the liver, the cæcum, the base of the heart, the venæ cavæ, the azygos vein, and the other lung composed of tree lobes.* The least suspicion of such a mal-location especially of the heart should, for reasons which shall be shown hereafter, put the physician upon his guard against every judgment that can have any relation to the state of the pulse.

The fact is, that in all the above mentioned irregularities of the heart, the pericardium has never failed to accompany and envelop it in every situation. The pericardium is in the form of a bag, and is composed of two membranes, of which the one is internal and named serous, the other external, and called fibrous. In this bag, is found the heart which

* Bichat, Recherch. physiol. sur la vie et la mort, pag. 14.

although perfectly free, cannot incline on one side more than another : its motions are powerful and alternate, and are regulated by the vigilance, the guidance and the support of the pericardium which keeps it suspended in a certain equilibrium : and the fact of the existence of the pericardium in all animals which have a heart, is an evident proof of the importance of the functions of the former, to the regularity of the motions of the latter. All the organic and animal functions would certainly be placed in disorder by the want of the pericardium, and life would in such a case be infinitely precarious.

The structure of the heart appears to be analogous with that of the muscles. This is so true, that in all ages the question has been agitated whether the heart should not be considered as another muscle. Galen replied in the negative, and founded his judgment upon the observation that the heart of an animal continues to move for a certain time after having been removed from the breast. A contrary opinion is however supported by many physiologists, among others, Dumas, who, although he admits that the fibres of the heart differ materially in their disposition from those of the muscles ; nevertheless insists upon considering

the heart as a muscle, though superior to all the rest on account of the elevation and eminence of its motions.

While we allow to Dumas, that the heart is composed of muscular fibres, for these at least appear to be very like, if not actually the same as those of muscles, nevertheless we must consider the opinion he deduces therefrom, viz. that the internal structure of the muscles, is consequently analogous with that of the heart, as altogether gratuitous. Without dwelling at length upon the confused and irregular manner in which the fibres of the heart are distributed and crossed in various directions, whilst such is certainly not the case with those of the muscles; (a circumstance which might alone suffice to decide the question to a certain extent,) we shall proceed to observe that the muscles belong to external or animal life; while the heart is the centre or focus of internal or organic life; that the exercise of the functions of this viscera does not depend upon the influence of the will, neither is its vitality modified after the model of that of the muscles, which certainly remain in repose and inactivity in a healthy state, when the command of the mind does not call them into action, or ceases to cause them to be in

exercise. It should not therefore be supposed that the muscles and the heart have a similar structure, when their functions, and motions are so evidently different.

Exclusively intent as were the ancient anatomists upon informing themselves as to the external disposition only of the fibres of the heart, they lost sight of the other object of studying and acquiring the knowledge of its internal structure ; hence they had but a confused and imperfect idea of it. In fact, from Hippocrates, to the time of Senac, the construction of the heart remained more or less obscure. Vesalius was the first who took up the enquiry seriously, but as he dissected the hearts of animals more than those of the human species, he only improved the knowledge of that organ as to its general structure. Lower was the next to develop in some degree the compliciteness of the fibres of the heart, while Senac by discovering their various dispositions and pointing out their probable direction, succeeded in giving an idea of the structure of the heart, much more conformable with truth. Lientaud extended the knowledge of the means to be employed in the anatomical analysis of the structure of the heart under every aspect. Harvey and Mal-

pighi by dint of experiments traced the gradual formation of the heart of a chicken, the progress of which they observed from its organization in the egg submitted to incubation; an experiment repeated by Lancisi with like success. Haller supplied many lacunæ, which embarrassed the structure of the heart, while Bichat prosecuted the study with still greater success. But notwithstanding so many distinguished anatomists of Europe have dedicated so much time and talent to acquire a knowledge of the construction of the heart, the secret of its organization still remains buried in obscurity.

Although the heart appears, and is in fact an organ *per se*, yet, it will be of great advantage, for the purpose of becoming acquainted with its structure, to examine successively the two ventricles, with their corresponding auricles. Such was the course pursued by Lieutaud and Bichat. The former by making the heart result from two bags, placed beside each other, suggested in like manner the idea of examining separately the two ventricles and auricles; and the latter concurred in keeping up the practice, with the distinction made by Bichat between the circulation of the red blood and that of the dark coloured.

“ Quoique ” says Bichat, “ les deux portions
“ du cœur soient assemblées en un organe
“ unique, cependant on peut les considérer
“ comme constamment indépendentes dans
“ leur action.”* We the more insist upon
the advantages of this method of examining
the ventricles and auricles of the heart separately,
because, we observe certain modifications of structure
in each, without their however ceasing on that account,
to be so many integral parts of one sole organ.

The left or posterior ventricle is the commencement of the arterial system, in which the circulation of the red blood takes place. Its form is pyramidical, and it exceeds the right ventricle in length, although both are nearly equal in breadth; which clearly shows that the left ventricle is naturally larger than the right, although Hippocrates, Lower, Santorini, Boerhaave and many others have thought the contrary. The opinions of anatomists upon this particular subject are, in fact, various. The reasons adduced by those who have maintained the greater capacity of the left ventricle, will be found in their proper place.

* Bichat. An. gén. Tom. ii. p. 247, 248.

Both ventricles of the heart are found to be composed of three tissues, two of which appear to be rather secondary ones, when compared with the third, which constitutes the fleshy substance properly so called: the tissues are: 1. The serous membrane of the pericardium: 2. The internal membrane of the pulmonary veins, through the left cavities of the heart, and the common membrane of the venæ cavæ through the right: 3. The muscular tissue, or fleshy substance of the heart.

The serous membrane extends all over the muscular tissue, from the auricle to the left ventricle, here spoken of, covering the posterior part of both. It does not differ from a prolongation of the internal serous membrane of the pericardium, and only serves as an external covering for the muscular tissue, or fleshy substance of the heart. Behind the above mentioned membrane, we find the muscular tissue. This is much thicker on the left than on the right side of the heart; it may also be said, that the left auricle and its corresponding ventricle exceed the right ones in power and strength, a strength corresponding to the necessity which the left ventricle is under, of resisting a greater column of blood, flowing into its receptacle, which we believe to exceed

in size that of the right ventricle. Another peculiarity which distinguishes the left from the right ventricle, is, that its parietes are not only more solid and thicker, but their fibres are also less confusedly distributed and crossed than those of the right one.

Upon a close examination, both of the external and internal fibres of the parietes of the left ventricle, it appears, that they proceed in a longitudinal direction from the base to the apex; but the fibres which compose the thickness or diameter of its parietes, are certainly not similarly disposed; their collocation is so irregular; the fibres in the thickness of the left ventricle are so crossed, that it has hitherto been found impracticable to disentangle and develop their intricacy with any degree of exactness; a difficulty which becomes still greater in the right ventricle, whose fibres, as before observed, are much more irregularly interwoven.

The external fibres of the left auricle appear to be rather in a transverse than a longitudinal direction, and the fibres constituting its thickness are also irregularly crossed. Both the auricles consist of two musculo-membraneous bags, communicating with the corresponding ventricles.

Lastly, under the muscular tissue is the above mentioned internal membrane, which as it proceeds immediately from the pulmonary veins, cannot but be an accessory part to the construction of the left cavities of the heart. After having passed through the internal part of the pulmonary veins, it immediately proceeds to line the left cavities of the heart, and thence successively all the internal capacity of the aorta, and of the branches and ramifications belonging to it: in the progress which it makes from the cavity of the auricle to that of the corresponding left ventricle, it doubles, folds itself up, and with its plicatures forms the mitral valves: thence it passes from the ventricle to the aorta, where it produces the three semilunar valves, by folding upon itself. I refer the reader to Bichat's general anatomy, where he will find a more particular explanation of the organization of the internal membrane passing through the left cavities of the heart, as well as over the whole internal superficies of the aorta.

If the left ventricle is the commencement of the arterial system, the right must necessarily be the termination of the venous one, through which flows the dark coloured blood. This ventricle has a triangular rather than a

pyramidal figure like the former one: the thickness of its parietes is much inferior to that of the parietes of the left ventricle, and the muscular fasciculi which there differ in volume, and from which results the right ventricle, assume, as before observed, a much more intricate form, than that of the muscular fibres of the left ventricle; because, whilst some of them take a vertical direction from the base to the apex; many others traverse and cross them in so many ways and directions as to form a reticulated tissue so irregular and shapeless as to render it impossible to ascertain the disposition of the fibres of the muscular fasciculi of the right ventricle.

The fasciculi which compose the body of the right corresponding auricle are double and of rare occurrence towards the base, but become small and more frequent towards its apex: they all, however, cross one another in net fashion.

In like manner as the left side of the heart, so is its right clothed externally with the above described serous membrane of the pericardium: with this difference, that a species of cellular coat consisting more or less of animal fat, intervenes between the serous and muscular tissue.

The other difference constituting a distinction between the left and right cavities of the heart, is, that the internal membrane which lines the second, is merely a continuation of the common tunic of the venous system, as it proceeds from the venæ cavæ to the auricle, and thence to the corresponding right ventricle; and it is precisely to the diversity between the internal membrane of the right cavities and that of the left, that must be ascribed the reason, why ossifications occur more frequently in the latter, than they do in the former. The internal membrane of the left cavities and of the aorta, which proceeds, as we have said, from the pulmonary veins, is in fact very often found ossified; but not so frequently, if scarcely ever, that of the pulmonary artery; a circumstance which determines the difference existing between the structure of the internal membrane of the system of the circulation of the red blood, and the tissue of the internal membrane of the system of the circulation of the dark coloured blood, of which we shall speak in another place. In the same manner as the internal membrane of the left cavities of the heart, that of the right cavities gives rise to the numerous valves, which are also necessary

for the successive flow of the dark coloured blood; in fact, proceeding, as this does from the *venæ cavæ* to the right auricle, the cavity of which it lines, it there folds upon itself at the level of the inferior vena cava, forming the Eustachian valve, below which it originates another smaller valve, called the valve of the cardiacal veins: in the space of the aperture of the right ventricle it produces by its folds the tricuspidal valves, which appear like so many membranous leaves; and in the aperture of the pulmonary artery forms likewise the three semilunar valves: which done, it extends itself over the whole capacity of the branches and ramifications of the pulmonary arteries, as far as the capillary system of the lungs.*

It is therefore an old error to consider the substance of the heart as a parenchyma, nor a less absurd one, to believe, that this organ is composed of two muscles united together. It is true, that at first sight, the two ventricles with their corresponding auricles appear two distinct bodies, but this apparent distinction is contradicted by facts. Instead,

* See Bichat. An. descriptiv. Tom. iv. appareil de la circulation.

therefore, of agreeing with Winslow, that the two ventricles of the heart are two distinct muscles, tied together by means of the fleshy septum, which is placed there; we believe, on the contrary, that the heart is one sole organ, adequate to the object of its functions, although apparently composed of two muscles or ventricles, which should be considered as integral parts of the heart itself. There can be no doubt of the identity of the muscular fasciculi, which all result from similar fibres, as well those composing the right, as those which form the left ventricle; and the above-mentioned fleshy septum which lies between them, is also made of similar fibres, proceeding from the inner parietes of both ventricles.

The modifications of structure, form, and solidity which distinguish the two ventricles, prove at most, that the left cavities of the heart correspond to the object of the circulation of the red blood, and the right cavities to that of the circulation of the dark coloured blood; but these two cavities do not the less constitute together one sole organ, viz, the heart. “*Les deux ventricules,*” says the celebrated physiologist Dumas, “*sont fortement attachés l’un à l’autre, et d’après une disposition telle,*

“que les fibres se croisent, se confondent, et
“semblent avoir une parfaite continuité.*”

It will be seen elsewhere, that the heart of the foetus is destitute of the above-mentioned fleshy septum, its place being supplied by the foramen ovale, which latter could in no way perform the office of the septum, were it true that its use is to unite and tie the two ventricles together and not to separate them, as it does, in order to preserve in this manner the arrangement which regulates the circulation of the blood. And whilst Winslow's opinion that the heart is formed of two distinct muscles, is at variance with the laws of the animal economy; it is equally inconsistent with the durability and solidity of the organ to consider it made up of more parts, a supposition which would not allow of its being equally solid and strong.

Hence, it appears more reasonable to consider the heart as a simple organ; and if it possess two ventricles and two auricles which give it the appearance of an organ composed of several parts, the reason is to be found in the mechanism of its functions; for, placed, as

* See Dumas. *Op. cit.* Tom. ii. p. 327.

the heart is, in the midst of the arterial and venous system, it necessarily required two cavities or ventricles, one, to receive the dark, coloured blood from the veins, and the other, to send to its destination the red blood, by means of the arteries. This is the reason why each ventricle has two orifices, of which the one is called auricular, through which the blood enters, the other arterial, through which the blood passes out. These four orifices are provided, as before observed, with valves, the use of which is to prevent the blood from making a retrograde movement. With respect to their form, those of the arterial orifices are called semilunar; those of the right auricular orifice, tricuspidal; and those of the left auricular orifice, mitral; while the Eustachian valve, so called, because discovered by Eustachius, terminates in the inferior vena cava, which communicates with the right auricle.

The order of the circulation of the blood therefore required that the heart should have two auricles, one on the right to concur in the partial mechanism of the right ventricle, and the other on the left for the purpose of corresponding in the same manner by its alternate movements, with the mechanism

of the left ventricle. Both have taken the name of auricles, from their resemblance to two small ears, and they consist, as has been said, of two little musculo-membraneous sacs, which present themselves externally at the base of the heart; with this difference, that the right auricle contains four, and the left five apertures: of the four apertures of the right auricle, two receive the two *venæ cavæ*, the third communicates with the right corresponding ventricle, and the fourth with the coronary vein; and of the five apertures of the left auricle, four are destined to receive the four pulmonary veins, and the fifth communicates with the left corresponding ventricle.

We have elsewhere observed, that the internal superficies of the auricles as well as that of the ventricles is lined with a particular membrane: with the difference there also noticed, that the one which lines the cavities of the left auricle and ventricle, is a continuation of the internal membrane of the pulmonary veins; while that which covers the cavity of the right corresponding auricle and ventricle is a continuation of the common membrane of the *venæ cavæ*. The former of these two membranes is smooth, white, and more or

less thin and brittle: it is most so, in the part which lines the ventricle, and the least, in that which covers the cavity of the left corresponding auricle. Its character is that of a tendency towards ossification, as we learn from dissection; for, the instances are very rare in which ossifications have not been found in the left cavities of the heart, or in the aorta; whilst they occur very rarely, if ever in the right cavities, and in the pulmonary artery. The second membrane is on the contrary, flexible, rather thick, and consequently capable of distension and dilatation to a certain point, which occasions the rare occurrence of the ossifications of the right auricle, of the corresponding ventricle, and of the pulmonary artery itself: this membrane instead of allowing itself to be burst or lacerated by the slightest application of force, as the internal membrane of the left cavities of the heart does, gives way. This remarkable difference of structure between both these membranes, does not allow either their office, or their different mode of feeling to be mistaken.

The red and the dark coloured blood being two distinct stimuli, it was necessary that the left and right cavities of the heart should be furnished with a different membrane, as in

the former the red blood was to circulate, and in the latter the dark coloured. Now, as the blood acquires the red colour in the capillary system of the lungs, a colour which is preserved along the whole track of the pulmonary veins, of the auricle and left ventricle, as well as of the aorta, the reason will easily be understood, why all these parts are in a direct continuity by means of the above described internal membrane, which proceeds from the pulmonary veins, and extends throughout the system of the circulation of the red blood.

The blood, upon leaving the ramifications of the aorta, loses in those of the *venæ cavæ*, the red colour, and preserves the dark coloured one which it then assumes throughout the round that it makes from the general capillary system to the capillary system of the lungs ; so that the *venæ cavæ*, the right auricle, the corresponding ventricle, and the pulmonary arteries, must all, (constituting as they do the system of the circulation of the dark coloured blood, whilst in a direct communication) be internally lined, as they really are, with a membrane different from that of the left cavities and of the aorta, in order that the sensibility of the one may obey the sti-

mus of the dark coloured blood, and that of the other, the action of the red blood.

The action of these two stimuli is in fact alternately succeeded, at one time, by the contraction of the auricles, and at another, by that of the corresponding ventricles ; a contraction which must be considered as the first spring of the circulation of the blood. This vital fluid driven out by the contractions of the heart, runs over all the internal and external parts of the body, by means of the arteries, and thence, by means of the veins, returns back again to the heart, from which it began its course: and thus, circulating from the heart to the different parts of the body, and from them back again to the heart, the blood ever thus continues its round, till the last moment of life.

That the exercise of the alternate contractions and dilatations of the ventricles and auricles of the heart, in which consists the mechanism of their functions, is the first spring which sets in motion the circulation of the blood, no one denies: in the act of contraction, which is called systole, the ventricles of the heart contract and shorten themselves with so much force, that their capacity is in fact at that instant obliterated, and with this

kind of contraction and shortening, which is a substitute for a smart shock, thrust, or impulse, they drive out the blood with much force, directing it along the arteries. To this effort succeeds an act diametrically opposite to the first, which is that of dilatation, expansion, or relaxation, this is called the diastole of the heart: in this act the ventricles resume their former dimensions, lengthening themselves, while their capacity returns to its first state: and with this kind of relaxation or interruption of the activity and action, the ventricles of the heart allow a free ingress to the blood, which is brought hither by means of the veins.

The circumstance, of the systole of the ventricles of the heart consisting in an impetuous and rapid motion, whilst their diastole is effected slowly, may be proved by opening the breast of an animal endowed with great tenacity of life, such as the cold blooded animals; these, as they are more capable of supporting the severity of such experiments afford more opportunity for observation than the warm blooded species. Upon opening the breast of an animal, the above mentioned action is clearly to be seen, viz. that the systole of the ventricle, or of the

heart, does not last an instant, whilst the time employed by its diastole or dilatation is comparatively long. By reference to a watch, it will be seen, for instance, that the ventricle of the heart of an eel, does not effect in the course of one minute more than thirty two oscillations; of the viper twenty eight, nor even more than fourteen the ventricle of the heart of the land tortoise, so that the time which is required for dilating the ventricle of the heart of such animals, and which intervenes between both its contractions, is considerable; evidently proving that the act of the diastole of the ventricles of the heart is passive and not active, as insisted upon by certain physiologists: the law of the alternation, of the state of activity and repose, rest, or inaction, which governs the economy of the vital organs, is the very same which prolongs their duration; and to suppose that the human heart has not the advantage of it, would be to accuse nature unjustly of ignorance or negligence, in having placed the heart, which is the chief organ of internal life, under the hard necessity of continuing in action without the least interval of repose, relaxation, or inaction. “*En examinant*” says the learned Dr. Serrurier “*le temps qui s’écoule*

“ entre le commencement d’une systole
 “ et celui de la suivante, on trouve que pen-
 “ dant la très-grande majorité de ce temps,
 “ les ventricules du cœur sont dans le relâ-
 “ chement.”* And in fact the auricles and
 ventricles of the heart do alternately re-
 pose themselves, for when those contract,
 these become dilated, and *vice-versa*; the ar-
 teries are only in action in the act of the dias-
 tole of the heart, and repose themselves in
 their turn by dilatation, while the heart con-
 tracts itself.

Long and obstinate controversies have di-
 vided, and still divide physiologists respecting
 the power which the heart possesses of con-
 tracting and dilating itself. Lower, in his trea-
 tise “ *De corde*,” has endeavoured to discover
 the cause of this power, and Drake redoubles
 his efforts for the same object, but fruitlessly.
 These and many other learned writers attri-
 bute the power possessed by the heart of con-
 traction and dilatation to the moving force
 with which the fibres are endowed, which,
 according to them, possess the natural ten-
 dency of shortening, contracting, and length-

* See Art. Pouls in the 44th vol. of the Diction.
 des sciences méd. p. 419.

ening themselves; in other terms, the fibres of the heart contract and dilate as they please, because they are capable of contraction and dilatation; this is reasoning in a circle. In support of their doctrine, they put in requisition not only the stimulus of the blood, but also the action of the muscles belonging to the ribs, the diaphragm, the air and various other stimulants, which we shall not dwell upon, as, in this second case, they confound the power which the heart has of contracting and dilating itself, with the act of its own contractions and dilatations. The subject of this controversy will shortly be discussed in the examination of the physico-vital powers of the heart, on which occasion the mechanism of its functions will be treated of more at length. The more we make ourselves acquainted with the different parts of the material instrument of the pulse, the better we are enabled to understand the mechanism of its motions. Hence, in order to be able to comprehend the manner in which the pulse produces its beats, all the various causes which concur in it, must first be studied and examined. This is the reason which induces us to trace the origin, principle or source of the motions of the heart and arteries.

ART. II.

OF THE PHYSICO-VITAL POWERS OF THE HEART.

WE consider it unnecessary, to seek for the power which the heart possesses of contracting and lengthening itself, in the cerebellum, as Willis has done ; or, with Lower and Drake to attribute it to various other agents equally foreign to the organization of the heart ; yielding to the force of new facts, we shall think ourselves justified in referring the above-mentioned power of the heart, to the union of the contractility and tonicity of its fibres.

And first, by contractility we mean the intrinsic power possessed by the fibres of the heart, of contracting, distending, and lengthening themselves independently of the command or stimulus of the will : as opposed to the irritability of the muscular fibres, which, as is universally known, exercise the reciprocal motion of contraction, and relaxation with the consent of the mind ; an observation and reason, on account of which it will here be necessary to remark the difference distinguishing both properties. From the apparent analogy between the contractility of the fibres

of the heart, and the irritability of the muscular fibres, several anatomists of the last century have been led to confound them with each other, as they designated both by the same name, irritability; a property of the motive fibre, which was indistinctly called *vis insita*, by Haller; *vis vitalis*, by Goerter; *oscillatio*, by Boerhaave; the tonic power, by Stahl; the inherent power, by Cullen; the muscular power and *vis motrix* by many other distinguished anatomists.

But notwithstanding the great resemblance there may exist between the contractility of the heart, and the irritability of the muscular fibres, we are not allowed to confound the reciprocal motion of the contraction and relaxation of the muscles, which are effected by means of the will, with the alternate systole and diastole of the ventricles of the heart and arteries, which are put in action or exercise by the specific stimulus of the blood, and not by the command of the mind: the more so, as the exercise of the functions of the heart and arteries, by a law of provident nature, ought not and cannot be interrupted, suspended, or completely destroyed by the stimulus of the will. This however cannot certainly be observed of the motion of the muscles, the exer-

cise of which is at times accelerated, slackened, and even completely suspended at the option of the mind. For the laws by which irritability is developed and governed, see Haller's treatise upon irritability, and also Crichton's work "*On mental derangement.*"

That contractility is a property of the tissue of the heart, and that its exercise does not depend upon the power of the will, nor upon the influence of general life, is a truth demonstrated by the experiment already made, and easily repeated, of removing the heart of a frog or of a tortoise from its natural receptacle, for the heart will be seen notwithstanding to oscillate in the air for a certain time, although it cannot make common life with the other organs of either animal. A similar phenomenon takes place in the heart, when removed from the bodies of serpents, fish, and even of certain mammiferous animals; for their heart does not cease to oscillate under the influence of the air for a certain portion of time after its extraction. Is not this a convincing proof that the heart, in consequence of the contractility of its tissue, can exercise its own movements of contraction and dilatation without the help of the cerebral organ, of the nervous fluid, or of the stimulus of the will?

Spallanzani, Boerhaave, Fontana, and many others, have often observed the contractions and dilatations of the heart to take place and succeed each other in various animals, notwithstanding a sharp cutting instrument had been introduced into their brain ; so that by this means, these experimentalists did not succeed in interrupting, suspending, or weakening, in any sensible degree, the contractions of the heart. Chirac, who has repeated similar experiments, relates a case in point, of a goose which lived twenty-four hours after he had separated the head from the neck, and during the whole time which the animal survived, the heart did not cease to contract and dilate, as if the creature had not suffered decapitation.

Bonnet, Vanderwiël, and others, have also observed the brain of children who have died of chronic diseases, and although that organ was internally lacerated, nay, even destroyed, they never, during the whole course of the chronic disorder, perceived any suspension of the contraction and dilatation of the heart : nor have the more serious injuries and disorders of the cerebellum, such as ulcers, scirrhus, sphacelus, and desiccation, been able to suspend the exercise of the functions of the heart. It is also well known, that it is not

rare for acephali to continue to live for a time, even after their entrance into the world. No such cases as those adduced could therefore have existed in nature, if the exercise of the contractility of the heart depended upon the influence of the brain, which is not found in acephali, or at least, only in an imperfect form.

A dog-fish of immense size had been caught at sea by the sailors of the American vessel in which I was a passenger; its head having been cut off, the animal still continued making violent and powerful springs; the heart was then taken from the breast, and did not cease oscillating for a considerable time afterwards; but its oscillations were observed to become more and more languid, till they entirely ceased; being at the same time irregular and uncertain. The animal being dead, its abdomen was opened, and in the right side was found a membranous bag of considerable weight, forming a receptacle for forty-two small fish, all of which, after an incision had been made, came out alive.

Here it may be said, that the difficulty does not consist in comprehending how the heart of a tortoise or of a dog-fish can oscillate out of the body of either animal; it is rather as to the means by which an animal can survive

the extraction of an organ of such great importance as the heart is, to the system of life. We shall first observe, that it does not follow because the function of the heart is of great importance to the animal economy, that such an organ must therefore constitute, or be of itself the essential and exclusive cause of the vitality of all the other organs of animals; besides, it is well known that zoophytes, worms, and insects, are unprovided with a heart, and that the crustacei and mollusca have scarcely a rude indication of it; notwithstanding which these animals live as long as the nature of their organization permits. Moreover, without being guilty of too much credulity, by giving a greater importance than they deserve to the accounts of Costa, Bacon, Bartolini, and other equally eminent writers, who have mentioned instances of persons having spoken, addressed prayers to heaven, and even manifested expressions of anger, after the heart had been torn from their breast; without, I repeat, giving way to credulity, by implicitly believing such relations, it is certain that some animals have walked, run, and cried, after they had been deprived of the influence of the heart. Muralt, Whytt, Haller, and others, have likewise examined frogs, tortoises, lizards,

vipers, and even cats, cocks, and dogs (the latter being warm-blooded quadrupeds), and in every instance found unequivocal signs of life, after they had been deprived of their hearts.*

Judging from the relation of Dr. Focale in his memoir upon an acephalus examined by him at Gioia di Bari, in the kingdom of Naples, the accounts of ancient writers, which at first sight seem romantic, should not appear surprising. This acephalous monster, he observes in his above-mentioned memoir, was without arms and heart, for in place of the latter, it had a small membranous lump situated in the lower belly, and destitute of motive fibres; there were also wanting the liver, the vena porta, the spleen, the pancreas, the omentum, and other parts of equal importance. The monster was by the side of a well-formed infant, which developed itself in the usual way, and was born two hours afterwards.

From all these facts, two inferences may be drawn; first, that the contractility of the fibres of the heart does not depend upon the general life, and that, by virtue of the exercise of this

* Whytt, on Vital Motions.—Haller, *op. cit.* Tom. i. p. 485.—Piso. *Hist. Natur. ind. lib. 5.*—Columbus *de re anat. lib. 12. p. 261.*

quality the heart can oscillate for a given time when out of the animal's body : secondly, that the presence of the heart is not necessary for a momentary life. But our view of the case is changed when we come to consider the heart as a conservatory organ of life : the life which is not nourished by the red blood by means of the heart, cannot direct and continue its course, of which we have a striking instance in drowned persons, or in animals which perish in the air-pump the moment the air is extracted. With respect to the facts reported of actions performed and words spoken, by persons who have been deprived of their heart, it is clear they could only have been momentary motions ; and how many of these would-be prodigies have not been worked upon animals subjected by experimentalists to the influence of the galvanic fluid ? All the wonder consists in the continuation of life, and not in that coarsening of it which can be accounted for by one physical cause or other. The other prodigy also ceases ; viz., that of a monster living for some time after being born, upon considering, that the brain, the heart, the liver, the spleen, the pancreas, and similar organs, are not at all necessary to life, when the latter is to be only momentary, and when nature in-

fuses it into a being formed upon a different type or model: for the better elucidation of this assertion, we shall quote some observations made by us in a former dissertation. “What is most important to know upon this subject, is, that sensibility and irritability are found in all living animals without exception; they are more developed in beings in which life possesses greater energy; they announce to us, by their action, the existence of the polypus which dwells in the cell, notwithstanding the appearance of a gelatinous substance deprived of life, and which only disappears when the animal perishes. This evidently demonstrates, that sensibility and irritability operating together, are the only vital functions. For, this display or exuberance of the functions, which in truth act a great part in the economy of the mammalia, serves only to answer the intention of nature, which designed to multiply the means of preservation in the most complex animals in such a manner, that if the chef-d’œuvre of creation could be only momentary, sensibility and irritability alone would be sufficient to cause him to exist.”*

* Rucco, a Dissertation on the General Principles of Anatomy and Comparative Physiology, *pag.* 22, 23. Philadelphia. 1818.

But the case, I repeat, is different, when we have not to consider a coruscation of life, or a being whose existence is momentary, or of short duration, whether by the disposition or aberration of nature. In every other case, the heart influences the circulation of the blood, and consequently the respiration and all the other functions of life; so that the relations which unite the heart with the other organs are so many and of such a nature, that it would be in vain to pretend, that the latter would continue to perform their functions, while the heart has ceased to act, so great and so complete is their reciprocal dependence.

But it is the tonicity, not the contractility, which is the cause of the ties that unite the heart with the other organs of man. In fact, besides contractility, the origin of so many phenomena, the aforesaid tonicity concurs also in the tissue, or to the organization of the heart. Now, by tonicity we understand that vital property of the tissue of the heart, by the help of which its fibres can feel, not only the action of the air, which its contractility obeys, when the heart is extracted from the animal, and exposed to the influence of the atmospheric fluid, but the specific and natural stimulus of the blood, to which the

tonicity of the heart corresponds, contracting and dilating itself regularly and in order ; this it could not do by contractility alone, which, in the last analysis, does not differ from a species of elasticity, or mechanical property of the fibrous tissue of the heart ; whilst the tonicity is confounded with its vitality, and depends upon the nervous influence, upon the peculiar organization of the heart, and upon the general life.

Tonicity was in fact necessary to a prolonged duration of the life of the heart, and of general vitality, in order that the exercise of its functions might be immediately connected with the preservation of the complicated machine of man ; and elasticity alone, which is subject to so many changes, would not be adequate to the task. By means of tonicity the heart maintains itself in relation with the other organs, and can at the same time always regularly obey the stimulus of the blood, which receives the shock from it, and thus commences the round of its circulation.

The heart certainly owes its tonicity or vitality to its organization, and it is the cardiac nerves there developed, which form part of its tissue, and most contribute to it. By this means, the heart reacts upon

the blood, and if it does so, which cannot be doubted, it proves that the heart is very different from a simple elastic body, destitute of tonicity, sensibility, or vitality. “L’opinion de Haller,” observes Pinel, “qui regardoit le cœur comme privé de sensibilité, et son irritabilité comme absolument distincte de la puissance nerveuse, pourrait-elle avoir maintenant des partisans, après les recherches faites par Scarpa sur les nerfs cardiaques,* et celles de M. Le Gallois, sur l’influence qu’a la moëlle épinière dans les fonctions du cœur?”†

Without the nervous power which renders the ventricles of the heart sensible to the action of the blood, they could not contract and dilate themselves, as they do, even when the blood possesses the power of passing from one cavity to the other without their assistance. The heart, says Baglivi, cannot put the blood in circulation with its contractions, without being furnished with nervous fibres, to which may be attributed the cause of its systole and diastole, and consequently of the distinct sensation to which the stimulus of the blood gives rise. The nerves of the heart have been

* See Scarpa, Tabul. Anat. ad lust. hist. nerv. cardiac.

† See Pinel, Op. cit. Tom. 3. p. 429.

clearly demonstrated by Vieussens, Willis, Winslow, Senac, Haller, and more recently by the celebrated Professor Scarpa, and by other learned anatomists. Another not less direct proof is the pathological phenomenon which occurs in the observation of the disorders which take place in the irregular motions of the heart and of the pulse, from the various affections of the mind; a phenomenon which is verified in every moment of life, and which could not occur, if the heart were deprived of nervous fibres, and consequently of tonicity or sensibility, although man is unconscious of it in a natural state.

The same phenomenon obtains, and is observed in the other internal organs, the excitability or sensibility of which is not however perceptible by man in a state of health. The intestinal canal, the liver, the spleen, the pancreas, the kidneys, and all the other internal organs, exercise their functions without the consent of man; his not perceiving this proves that his organs are in a sound and healthy condition; because, in case of illness, he would not fail to point out to the practitioner the seat of his pain or affection. The reason of this is found in the peculiar character of the nerves which proceed from the various ganglia; these latter render independent of the will the

functions of the internal organs to which they send nerves, which nerves communicate to them motion and vitality, being the active instruments of internal or vegetative life, in contradistinction to the cerebral nerves, whose office is that of imparting activity to the organs of sense, motion, and speech, and of rendering them sensible to the action of external bodies. All the other organs, except these, have an existence isolated and independent of the will, and place themselves in activity or repose without our participation. By this means it becomes more easy to understand the reason why the heart, which is endowed with internal, organic, or vegetative sensibility, performs its contractions and dilatations independently of the will. And if this were not the case, mere forgetfulness, or absence of mind, a single moment of delirium, would suffice to put an end to life ; and all criminals condemned to death, as well as those persons whose existence was a burthen to them, would destroy themselves, by arresting at will the motions of the heart, if wise and provident nature had not intrusted the exercise of them to the nerves of the ganglia, or to the internal life. We shall now proceed to consider the other part of the material instrument of the pulse, the arteries.

ART. III.

OF THE ARTERIES.

THE arteries, which we shall now examine, originate in the heart. The arteries are so many membranous, elastic, and small pulsatile canals, which in proportion as they recede from the heart, become gradually smaller, till they at length form, at the extremity of the body, where they terminate, a species of net, thence called arterial. Almost all the arterial vessels then discharge themselves into the venous ramifications, which commence at the point where the arterial ones terminate; and those vessels which do not find venous ramifications free to receive them, unite themselves together by anastomosis.

Finally, it is well known, that the ancient physicians first gave the name of arteries to these canals, because they erroneously believed that air, and not blood, circulated within them. “*Primis nempe vetustissimis medicinæ temporibus,*” says Cirillo, “*dum medici arterias spiritum, venas sanguinem continere existimabant, arteriæ vasa pneumatica dicebantur.*”*

* See Domenico Cirillo, *de Pulsibus*.

All the arteries which are susceptible of anatomical analysis, are found to be composed of three tunics or membranes ; except, however, the arterial trunks, which receive, as is well known, a fourth coat, although an accessory one, from the membranes which line the great cavities of the body. Such is the case with the aorta, which is covered first, by the pericardium and pleura in the cavity of the thorax, and secondly, by the peritonæum in the abdomen.

The first, or outermost membrane, is called the cellular tunic. Albinus, on account of its whiteness, gave it the improper name of tunica nervosa. Vesalius, that of tunica cartilaginosa, and Heister that of tunica tendinosa. The fact is, that its structure has much analogy with that of the cellular membrane properly so called, although that coat is rather thick, narrow, destitute of fat, and consequently firmer and more solid than the cellular membrane itself. The outermost tunic contributes to preserve the folds of the arteries which it covers, and can sensibly distend and dilate itself. It is this external tunic of the arteries which becomes dilated in aneurisms; for in however small a degree these arterial tumours become enlarged, the other ar-

terial tunics, as we shall see, cannot, considering their fragility, but break, and become lacerated. Aneurisms therefore occur only in this cellular tunic, as soon as the other arterial membranes are incapable of dilating themselves in the presence of arterial tumours somewhat enlarged; and this is the reason why true aneurisms never occur in surgery.

The second is called, the proper membrane of the arteries; it is of a yellowish colour, composed of different strata of fibres, somewhat circular, and has taken the true name of *tunica fibrosa*. The thickness of its tissue varies from the trunks to the ramifications; it is rather thicker and narrower in the trunks and branches, and less so in the arterial divisions and subdivisions, in which its tissue diminishes so gradually, as no longer to be perceptible in the last arterial ramifications: It possesses also another peculiarity, which is, that the fibrous tunic is narrower, thicker, and more solid in the arteries which are distributed among the muscles, and less so in those which belong to the organs and viscera of a more fragile and delicate structure. It is therefore an error to give it the name of muscular membrane, as is still done by many anatomists, without reflecting, that

the fibrous tunic of the arteries differs materially from the true substance of the muscles: besides, the muscular tissue is soft, and very susceptible of extension, whilst that of the artery is solid and incapable of it, and breaks rather than gives way: equally false is the idea of assimilating the structure of the arteries with that of the muscles, as it is in contradiction to the result of the analysis of the arterial tunics made by Berzelius, who did not find the least particle of fibrine amongst the other component parts.

Dr. Young has, with similar diligence, repeated the same analysis of the arterial tunics, confirming the result of that made by Berzelius, not having been able to discover the smallest atom of fibrine. Besides it is generally known, that it is the fibrine which determines the true character of the substance of the muscles; and if, as chemical experiments prove, the fibrous tunic of the arteries differs from the real muscular substance, the old custom of calling it the muscular tunic, can certainly in no way advance the progress of anatomy and physiology: so much the more so, as the arteries perform their functions independently of the will, which is diametrically the reverse with the muscles; more-

over we do not perceive the least reason, why the structure of the arteries should participate in that of the muscles. “ Il est hors de
 “ doute,” says Bichat, “ qu’il n’est aucun
 “ tissu aussi fragile que l’artériel; aucun, par
 “ conséquent, qui soit moins propre à être
 “ embrassé par les ligatures. Pourquoi faut-
 “ il que ce soit le seul où il est nécessaire de
 “ les appliquer? Ce phénomène seul distin-
 “ gueroit le tissu artériel du musculaire.”*

Lastly, to the fibrous membrane succeeds the common tunic of the arteries, appropriated to the circulation of the red blood, and with which, as before observed, the whole of their internal cavity is lined. This is the only part which establishes the union of the left cavities of the heart with the aorta; because, by its means, both form one canal, through which the red blood flows. In proof of which, Bichat relates his having removed the internal membrane of the arteries from their fibrous or proper tunic, to which it adhered so lightly, that he could separate it under the form of a canal, equal in length to the whole extent of the system of the circulation of the red blood. The common membrane of the arteries, as we

* Op. cit. Tom. ii. p. 282.

have said, is then transparent, white, smooth, and so fragile as to be lacerated or broken upon the application of the least force. Some anatomists believe that an oily fluid lubricates and moistens the internal superficies of this tunic, because the delicacy of its structure is preserved. This fluid is attributed by some to the exhalants, and by others to the presence of a species of cellular substance, which they believe to exist between the fibrous tunic and the common membrane of the arteries. Bichat denies the existence of this cellular substance, in opposition to the opinion of Haller, who admits it: from the facility with which the common tunic ossifies in the trunk of the aorta, where it is less thin, and where the above-named oily fluid should proportionably abound, and prevent its desiccation and ossification, the admission of its existence appears to be altogether gratuitous.

On account of their diminutive size, the arteries of arteries escape this sort of anatomical analysis: *arteriæ arteriarum* is the name given by anatomists to the capillary vessels which administer to the arterial tunics the various juices and nutritive fluids of which they stand in need for their preservation: and in case of an overflow of white or red fluids

into these tunics, the lymphatic capillary vessels, which are in the middle of the tunics, absorb them. In fact many small arteries are seen winding along the sides of the arterial branches of a fœtus, since the thinness and transparency of their coats allow the capillary vessels to be better observed in this, than in any other period of life: besides, the arteries which are destined to distribute the nutritious fluid to all the other parts of the body, must for that purpose develop themselves prematurely; a circumstance which will explain the reason why, under similar circumstances, the arteries of the fœtus are proportionably larger than those of the adult, and consequently more accessible to inspection. The preservation, therefore, of the life of the arteries, depends upon the office of the small arteries or capillary vessels, which are distributed with wonderful order through the tunics of the trunks, of the branches, and of their divisions and ramifications: although the capillary vessels themselves cannot be discovered in the last arterial divisions and ramifications, the certainty of the preservation, or mode of life of the whole arterial system, conduces at least to the certainty of the mechanism we have described: nevertheless, it would be impossible to see the trunks, branches, and

the last arterial ramifications, live and preserve their existence, if all these parts were not endowed with an internal animating power, which resides exclusively in their organization: to this the small nervous threads which come from the ganglia, animating and protecting the whole system of circulation of the blood, especially concur by their nervous irradiations.

The system of the circulation of the blood results from the union of the heart, the arteries, and the veins. All the arteries and veins which are destined to the general circulation, or to the two circulations of the red and the black blood, may be reduced to two classes of vessels; viz. to that of common vessels, and to that of proper vessels. In the first are included: 1. the aorta; 2. the pulmonary arteries; 3. the venæ cavæ; 4. the pulmonary veins: and in the second class we find the arteries and the coronary veins.

The aorta originates in the left ventricle, and the pulmonary artery in the right: this artery is the limit of the general system of the circulation of the black blood, the object of which is to impel this fluid, in the state in which it receives it, from the right ventricle of the heart into the lungs, where the blood comes

into contact with the air; and becomes immediately changed from black to red. It is in the pulmonary veins, which represent the beginning of the system of the circulation of the red blood, and through these in the capillary vessels of the lungs, that the colouring of the blood actually takes place. The capillary vessels of the lungs form a particular system; a system which exists between the ramifications of the arteries, and those of the pulmonary veins, which, being the nearest to the aereous conduits, allow the black blood to come in contact with the air; and it is in this reciprocal meeting of the two fluids of the blood and air, that the chemical process of the colouring of the blood takes place.

The pulmonary artery divides itself into two trunks, before effecting a junction with the lungs: it then subdivides itself, conformably with the number of the lobes of the lungs, into five other smaller branches, which there distribute themselves: from these proceed as many other still smaller branches as there are aereous conduits: so that these aereous conduits and the branches of the pulmonary arteries are continually multiplying in concert one with the other, and for this reason, having gradually become smaller, at length escape the

acutest search by their extreme minuteness; they then justly take the appellation of capillary vessels.

The aorta is not, as some suppose, a prolongation or lengthening of the substance of the left ventricle: the only part which places it in a direct continuation with this ventricle is the internal common membrane, which proceeds, as we have observed, from the pulmonary veins, and extends and prolongs itself without interruption as far as the last ramifications of the aorta, passing along the left corresponding auricle and ventricle. On the left ventricle, the aorta divides itself first into two principal branches, of which the first, because it takes an upward direction, for the purpose of reaching the neck, the head, and the upper extremities, takes the name of the ascending aorta: the other branch is called descending, as it directs its course towards the breast, the abdomen, and the other lower extremities of the body. From the ascending aorta proceed the internal and external carotidæ, the subclavian arteries, and, so to speak, all the other branches of the second, third, and fourth order, which are derived from it; from these branches originate almost all the

ramifications and capillary vessels which are distributed in different ways in the brain, in the face, and in the upper extremities, for a purpose which will be shown in its proper place. The iliacal and hypogastric arteries, and all the other divisions and subdivisions which originate in the descending aorta, discover themselves in various forms in the viscera, muscles, and all the other parts of the lower extremities.

Where the last ramifications of the pulmonary arteries terminate, those of the pulmonary veins originate: these keep gradually increasing in bulk, after which they become united into four trunks, which discharge themselves into the left auricle.

Where the last ramifications of the aorta terminate, those of the *venæ cavæ* commence; these also continue gradually increasing, in proportion as they approach the right auricle, where the two *venæ cavæ*, produced by them, terminate.

The coronary arteries originate in the aorta, and are divided and subdivided, in order to be distributed over the whole substance of the heart, and over the sides of the commencement of the aorta itself. In the place where the

coronary arteries terminate, is found the origin of the coronary veins, and these communicate with the right auricle.

From this hasty sketch of the various parts which concur in the system of the circulation of the blood, a general idea may be formed of the object which nature proposed to herself in this her complicated work.

In this manner has nature effected her object; by the distribution of the above-mentioned arteries and veins into a prodigious number of branches of every calibre, and of ramifications of every kind, arranged and disposed with so much skill as the arteries and veins are over all the other organs, and in all the internal and external parts of the human machine, nature has succeeded in fixing, not only the seat of the arterial circulation of the red blood, the object of which is to pour into them the ever-new elements of their nutrition and preservation, but also the seat of the circulation of the dark-coloured blood, to which is confided the double charge, first, of repairing the loss sustained by the red blood, from being deprived of every nutritive principle in its round through all the organs and viscera of the human body; and secondly, of reconducting it to the right ventricle of the heart,

in order that, by this means, the dark-coloured blood may pass to the lungs, where it becomes charged with new elements, and re-acquires the red colour.

For this purpose, the right ventricle contracts itself in the presence of the stimulus of the dark-coloured blood, and by this contraction strikes, presses, and powerfully expels the blood from its cavity towards the pulmonary artery; whence the blood successively passes into the branches and into their ramifications, for the purpose of penetrating into the capillary system of the lungs; where, as has been observed, occurs the phenomenon of its change of colour: from the capillary vessels the blood progressively proceeds from the smallest to the largest branches of the pulmonary veins, and thence to the left auricle, which contracts in like manner, and impels it into the corresponding left ventricle.

In its turn, the left ventricle, which contracts itself with greater force in the presence of the red blood, expels anew this vital fluid, and drives it from its cavity to direct it along the aorta: then the red blood, which also by the contractions of this artery is urged on to proceed, enters the largest

sphere of its divisions and ramifications, and thus diffuses and spreads itself through the organs, viscera, muscles, and all the other parts, both internal and external, of the human machine, into which have been poured, as before observed, new nutritive fluids, which have come in contact with the air upon passing through the lungs. The aorta, therefore, is that organ which transports the new elements so necessary for the preservation of life; because it is well known that the bronchial arteries, which bring the proper nutriment to the substance of the lungs, and to the pulmonary veins, originate in the arterial aorta, and terminate where the bronchial veins commence, which communicate with the vein azygos, or vein *sine pari*; which latter discharges itself into the upper vena cava. The origin of the coronary arteries, which convey the nutritive principles to the substance of the heart, the strength and energy of which they support, is the same, as they proceed from the aorta.

From the capillary system of the aorta, where the blood, after its circuit, becomes dark-coloured, this fluid passes into the ramifications of the venæ cavæ, and successively to their branches, from the smallest to the largest; and by this means rejoins the dark-

coloured blood in the right auricle, where the *venæ cavæ* deposit it ; thence impelled by its contraction, it cannot fail reaching the corresponding right ventricle, whence it set out, and began to make its natural circuit : such is the function which physiologists term the circulation of the blood.

All physiologists agree in two facts : that the blood is renewed upon coming in contact with the air, and that the aorta is the means which nature avails herself of to distribute the nutritive juices or elementary principles to the different parts of the body : but they are not all unanimous as to the manner in which the circulation of the blood is performed. Modern writers, amongst others the celebrated Dumas, do not, indeed, admit that the motions of the auricles and ventricles of the heart, are made in successive order, as we have before described. Nicholls's method of making the blood successively proceed from the right to the left ventricle of the heart certainly appears more simple ; but this hypothesis is in opposition to the structure of the heart ; because neither the auricles nor the ventricles can contract themselves in an isolated manner, for the reason that the partial motion of each cavity is incompatible with the uniformity of

its structure, because the fleshy septum which divides one auricle from another, as well as that which divides one ventricle from the other, is made, as already noticed, of similar fibres, which proceed from their parietes, and entwine and unite strictly with each other: now it is this intimate connexion between both auricles and ventricles which will neither allow one auricle to contract, nor one ventricle to be set in action, without the other. The ventricles can act independently of the auricles, and these latter can act independently of the former; for their connexion is not so intimate as to lead us to think that the contraction of the former cannot take place without that of the latter: but the motion of the two ventricles and auricles is so well fixed, that the right ventricle cannot contract itself without the left, nor the left auricle without the right. “Les deux oreillettes,” says Dumas, “se contractent d’un seul coup, en même temps que les deux ventricules sont dilatés. Ensuite les oreillettes se dilatent; alors les ventricules sont contractés, et ils le sont, de même que les oreillettes, par un mouvement commun.” *

* Dumas, Op. cit. Tom. ii. p. 381.

The organization, or the arrangement of the structure of the heart requires, therefore, that its ventricles, both right and left, should contract simultaneously, in order to drive the blood, the first into the pulmonary artery, and the second into the aorta: the pulmonary artery conveys the blood into the pulmonary veins, and the aorta into the venæ cavæ; the former discharge it into the left auricle, and the latter into the right one; both auricles contract themselves simultaneously in like manner, and throw the blood at the same moment into the corresponding ventricles from which it begins to make its circuit.

Having thus fulfilled our purpose of recalling to the reader's mind, in a general way, the mechanism of the circulation of the blood, of which we shall treat more at length in our inquiry into the causes of the different pulses, it is now expedient to point out the origin of the power which enables the arteries to oscillate and beat in the state of life.

ART. IV.

OF THE PHYSICO-VITAL POWERS OF THE ARTERIES.

LIKE the heart, the arteries have the power of contracting and dilating themselves alternately, in the presence of the stimulus of the red blood. That the red blood, by its particular character, contributes to the beating of the arteries, is proved by Bichat's experiment for making the red blood circulate in the veins. For this purpose, Bichat applied to the carotid artery, and the external jugular vein of a living animal, two curved tubes or conduits; and by this invention he made the red blood pass from the carotid artery into the jugular vein, both being previously prepared for the performance of the experiment. Scarcely did the red blood commence its passage into the jugular vein, when he observed that the latter gave signs of a species of isochronic oscillation at the beating of the heart, similar to a murmur, noise, or obscure pulsation, which could only be derived from the specific action of the red blood, which on account of its not finding (during such an ex-

periment) the same organic dispositions of the arteries, in the veins, produces in the latter a species of obscure pulsation, and a decisive and more sensible beat in the former. Cirillo attributes to the expansile animal vapour, the property possessed by the arterial blood of contributing to the beat of the arteries; his words are these: "*Arteriarum itaque pulsatio non modo sanguini, sed præsertim vapori expansili animali dicto originem debet:*" thus it is very probable that Cirillo had some idea of the discovery of oxygen; for he adds, "*Ab hoc rursum vapore pendet præcipua differentia, quæ inter arteriosum, et venosum sanguinem observatur.*"* Thus it appears clear, from the experiment of Bichat, and from what Cirillo advances upon the subject, that the oxygen of the arterial blood takes part in the beat of the arteries.

Now, the power possessed by the arteries, of contracting and dilating themselves in the presence of the specific stimulus of the red blood, which causes them thus to act, resides, like that of the heart, in the concurrence of the contractility and tonicity, particularly of the fibrous tunic, which con-

* See Domenico Cirillo, *de Pulsibus*.

stitutes the most important part of the organic tissue of the arteries. The contractility or elasticity of the arteries resembles that of the heart, and consists in the physical power which they possess of resuming their first dimensions, at the very instant the cause which produced their contraction ceases. To this in every respect mechanical or physical property, the arteries are for the most part indebted, as we shall see, for the power they have of resuming their cylindrical form, the moment that fluid ceases to act upon them in the accustomed manner. But their contraction and dilatation would certainly not be of long duration, if the circumscribed power of the contractility of their tunics were not seconded by tonicity, to which is owing the constant and regular order of their contractions and dilatations.

Bichat makes a difference, upon what grounds I know not, between the elasticity and the contractility of the arterial tunics, as if both were not two physical or mechanical qualities of the arteries confounded together. “*L’élasticité,*” says Bichat, “*est une propriété purement physique. La contractilité*” “*de tissu, sans être vitale, n’est inhérente*

“ qu’aux organes des animaux.”* If the contractility of the tissue be not vital, it must of necessity be mechanical or physical; because there are no intermediate qualities between the physical and the vital ones. If a quality does not belong to the *simple*, it must necessarily be referred to the *living* solids. For this reason we blend together the elasticity and the contractility of the arteries, as neither of them differs from the physical or mechanical quality of the arterial tunics.

This is not the case with tonicity, which differs not, as will be seen, from a vital property of the arteries: this property is such as does not allow us to confound the arterial vessels with the other numerous canals, which are only elastic, and entirely destitute of vitality or excitability; this is that property which extends the limits of their power, and guarantees its regularity and duration. The advantageous idea which we have thus formed of the character of the tonicity of the arteries, arises not only from the suppression of different hemorrhages of these vessels, which medical men would never have been able to

* See B. An. gén. Tom. ii. p. 305 & 306.

effect by any means, had they not been seconded by the vital action, which is the same as the exercise of their tonicity or sensibility; but also from the successful result of the ligature, which is practised in different surgical operations; for, if the tonicity of the arterial tunics were not gradually opposed to the arresting the course of the arterial blood, whilst the ligature only prevented the impetuous discharge, the arterial hemorrhage would certainly re-appear as soon as the ligature was removed; a circumstance which does not happen merely on account of the influence of the vital action, or of the tonicity, which are synonymous. Add to this another observation; viz., that the cavities of the arterial vessels, when cut in the amputation of any member of the human body, become perfectly obliterated, inasmuch as they contract, shorten, and gradually close up their sides, by the power of the tonicity which proceeds from their organization. It is therefore not credible, that such an effect of the vitality of the arteries is derived or produced from the mechanism of the contractility of their tunics, as well because it is at variance with the easy alteration of this physical quality, whilst the effect of the obli-

teration of the cavities of the arterial vessels is constant, successive, and internal; as because the contractility of the tissue, according to Bichat, has but little or nothing to do with the internal affairs of the organization of the arteries.

The above observations, therefore, militate against the opinion of Bichat, who, whilst he gives to the tonicity of the arteries the name of contractility for want of extension, “*Contractilité par défaut d’extension*,” erroneously considers it as a property independent of life; as if the contraction of the arterial tunics, to the extent even of entirely obliterating the cavities of the arterial vessels (as is observed in the case of members which have suffered amputation, and have afterwards been cured), did not occur only in the state of life. The tonicity of the arteries in fact disappears with the organization, whilst the contractility or elasticity of the arterial fibres remains in action for a certain time after the death of the animal, as we shall have occasion to observe in another place.

Bichat was led to think thus, from another opinion entertained by him, that of believing in the actual insensibility of the nerves which are distributed through the arteries; whilst

he afterwards confesses that the introduction of any irritating fluid whatsoever into an artery (for instance, ink, acid in a liquid form, wine, &c.) causes it a very severe pain or uneasy sensation; a sensation, which only takes place, it is well known, in parts which are sensible and excitable. He likewise believes, that the capillary arteries can make the blood circulate by the mere exercise of the insensible organic contractility, as he calls it, of their tunics. “Montrer” says Bichat, “où le système capillaire commence, “ et où les artères finissent; c’est chose difficile. On peut bien établir que c’est là “ où le sang cesse d’être entièrement sous “ l’influence du cœur, pour ne circuler que “ par l’influence de la contractilité organique “ insensible des parois vasculaires.”* Bichat then concludes by admitting the capillary arteries to have vital motion; that is, sensibility, when he says, “Le cœur est presque tout pour “ le mouvement du sang, seulement dans les ra- “ muscules, c’est en partie le cœur et en partie “ l’action vitale des artères, qui concourent à “ ce mouvement.”† Which does not agree

* See Bichat, An gén. Tom. ii. p. 276.

† Ibid. p. 328.

with the other general principle, that the organs or parts similarly constructed possess the same qualities, and exercise the same functions. All the large and small arteries result, as before observed, from three tunics, and if the various capillary arteries escape anatomical analysis, this imperfection of the art, or of our senses, will not allow even Bichat to infer that the structure of the capillary vessels is different from that of the trunks and arterial branches; the more so as both constitute together the arterial system: and it would be equally absurd to imagine that the tissue, structure, or organization of the arteries is not homogeneous and uniform. Hence it is impossible for us to say, why the vital action, which we consider to be the same as tonicity or sensibility, should reside in the capillary arteries alone, and not in the whole arterial system.

The fact is, that tonicity is inseparable from the organization, and from the vitality of the arteries; and does not differ from their excitability. Without adducing a crowd of observations, capable of showing the truth of this assertion, we shall consent ourselves, only observing that the ligature of any artery whatsoever imparts a sensation of pain, a pain

evidently caused by the unusual action of the instruments employed for the purpose; and that in the dead bodies of many persons who have died of inflammatory fevers, the internal membrane of the arteries has been found extremely red; a proof that the arteries are capable of becoming inflamed, and consequently that they are sensible and excitable. “Toute cause physique ou morale,” observes Dr. Pinel “propre à établir une réaction forte et durable sur le système vasculaire sanguin, peuvent produire la fièvre inflammatoire.”* Now how could the arteries react, and how could inflammatory fevers result from their strong irritation, if they were not sensible and excitable? In support of this inference, may be adduced the authority of John Peter Frank, who says, “*In vehementissimis inflammatoriæ naturæ febribus, sub enormi cordis, arteriarumque agitatione, non modo has ipsas; sed venarum totam compagem, interna superficie undique profunde rubentes ac inflammatas nos primum conspeximus, similesque arteriæ, inprimis magnæ, phlogoses partiales, sub iisdem circumstantiis, jam pluries ostendimus.*”†

While, therefore, we do not concur with

* See Pinel, Op. cit. Tom. i. p. 19 & 20.

† See J. P. Frank, Epitome, Lib. i., p. 187.

Bichat in his opinion that the blood in the capillary vessels does not retain a residuum of motion, communicated to it by the contractions of the heart, and by the systoles of the arterial trunks; his other principle seems to be equally in opposition to the excitability or tonicity of the arteries; viz., that of considering, as Herophilus had done before him, the arterial vessels as so many elastic, passive, and insensible tubes; as if the circulation of the blood were a function wholly mechanical, or performed by physical means, and not by organized, excitable, and sensible vessels.

The tonicity, therefore, of the arteries, differs from the muscular irritability, not only on account of the defect of the fibrine, which is wanting in the arterial tunics, whilst it exists in muscular tissue; but because, also, it does not, like the irritability of the muscular tissue, obey the power of the will: thus, the arteries are not capable of contracting themselves as the muscles do, in consequence of the action of other stimuli, whether chemical or mechanical. It is only, as before observed, the red blood which can be obeyed by the tonicity of the arteries; because, whatever other stimulus be applied to them, not the least contraction is produced.

The degree of tonicity, however, of the ar-

teries, differs in individuals of either sex, and of different ages; conformably to the condition of the physical constitution, and according to the state of general health or disease. The degree of elevation of the tonicity of the arteries always follows the condition of the strength of the constitution, and the greater or less energy of the vital powers. It is not, therefore, of rare occurrence, to observe, at one time, the elevation of the tonicity of the arteries to the highest degree, as is the case in the course of the inflammatory fever of the first order; at another its deterioration, as happens in the various kinds of dropsy, and in diseases of extreme languor; and at another its approaching cessation, as is the case in paralysis, and hemiplegia.

For the purpose of proving the existence and the degree of elevation of the tonicity of the arteries, the indefatigable and profound anatomist, John Hunter, undertook to make some ingenious experiments, not only upon the arteries of horses and other quadrupeds, but also upon the arteries of the umbilical chord of the human subject: the object, however, which Hunter had proposed to himself, was not borne out by the results of his experiments, which, at the most, proved that the

arterial vessels of the said umbilical chord preserved the power of contracting themselves even two days after it had been separated from the placenta, which Hunter himself deduces from his experiments. "These experiments," he says, "shew that the vessels of the chord have the power of contraction above two days after separation from the body."* In order to succeed in satisfying himself of the degree of tonicity of the tunics of the arteries, this distinguished anatomist should have seized the opportunity of extending his experiments to the arteries in the state of life, or at least as short a time as possible before the organization had abandoned them together with the tonicity, which follows it every where: in other respects, his experiments have the merit of having pointed out to his zealous successors, the kind of researches required by physiology to verify the existence and the degree of tonicity of the arteries.

Among other zealous successors of John Hunter, the learned Dr. Caleb Hillier Parry deserves particular mention: this physician has repeated, in the most ingenious manner, the same experiments upon various arteries of

* See J. Hunter, *A Treatise on the Blood*.

different living animals, and thus has multiplied the proofs which demonstrate, at one time, the existence of the tonicity, at another, the proportions in which are found compounded together, in the arterial vessels, the tonicity and the contractility, in which resides, as before observed, the power which the arteries possess of contracting and dilating themselves in the presence of the stimulus of the red blood.

With this object, Dr. Parry caused Mr. George Norman, an able surgeon, to repeat, in the presence of two of his pupils, the following experiment among many others: we shall give the doctor's own words. "The carotid artery of a living ram having been detached from all the surrounding parts, its circumference was accurately measured with some fine thread, and found to be $\frac{260}{400}$ of an inch. The animal was then killed by a cord passed round the trachea, without including any other part. The artery being again measured precisely in the same spot, within five minutes after apparent death, was found to be in circumference only $\frac{190}{400}$ of an inch. Thus the circumference appeared to have been reduced $\frac{70}{400}$ of an inch.

“ In order to discover whether any, and how much, of this reduction depended on tonicity, it was presumed that a subsequent period might be found, when the tonic contraction would be entirely lost, and the artery would be brought to that state, which was the result of the mechanical power of elasticity.

“ Accordingly, twenty-one hours and a half after the last measurement, putrefaction having already begun about several parts below the diaphragm, the artery was measured in the same place a third time, and proved to be in circumference $\frac{222}{400}$ of an inch.

“ Hence, of the whole contraction of the circumference, or $\frac{70}{400}$ of an inch, that by tonicity was $\frac{32}{400}$ of an inch, and that by elasticity $\frac{38}{400}$.”* According to the result of this experiment, not the smallest doubt can henceforth remain upon the existence of the two powers of the arteries; I mean the contractility and tonicity, which are found in them in the proportions stated.

From this, and several other experiments

* See C. H. Parry, *An Experimental Inquiry into the Nature, Cause, and Varieties of the Arterial Pulse*, p. 60 & 61.

which form the principal subject of Dr. Parry's work, it will be obvious how inconvenient it would be to maintain with Bichat, that the contraction of the arteries is the product of elasticity alone. In this ill-founded opinion Bichat was preceded by the physiologist of Berne, Haller; at least such is the sense in which the following words must be taken: "*Phænomena eo loco narravi, negavi conspicuam in minimis arteriis contractionem reperiri; et nunc sincerus aliud phænomenon propono, quod non videtur absque aliqua contractione intelligi posse: ea vero contractio a vita non pendet, neque musculosæ est indolis, quæ a morte supersit, et ad nativum potius elaterem tensæ fibræ cellulosæ spectat.*"*

And we, on the contrary, conclude that the power which the arteries possess, of contracting and dilating themselves, arises from their contractility and tonicity; that the tonicity is inseparable from the organization, and from the state of life, and that both these powers of the arteries obey and answer to the stimulus of the red blood, which can alone set them in action. By this means we are now enabled to comprehend what relates to the mechanism and causes of the beating of the pulse.

* Haller, *Op. cit.* Tom. ii. p. 215.

ART. V.

OF THE MECHANISM AND CAUSES OF THE PULSE.

THERE has certainly hitherto been much difference of opinion among physicians concerning the mechanism and causes of the pulse: this subject has, however, at all times animated the zeal, and awakened the attention of the most enlightened physiologists, and of the most distinguished members of the faculty: a convincing proof of which may be found in the various changes that in every age *Sphygmica* has undergone; a science of which the progress has always been tinctured with the taste of the different schools predominating at various periods.*

But although the majority of opinions respecting the mechanism of the pulse have been exhibited in the preceding historical sketch, it will nevertheless be advantageous, for the sake of greater clearness and precision, to pass in review, not only the opinion of Galen, which has more or less influenced those of his successors, but also, by means of new facts, to sift and examine the newest and most prevailing

* See History of *Sphygmica*, p. lxiv.

ideas of the present age upon the same subject; examining them with impartiality, and assigning the reasons which prevent us from adopting them; it is our intention to proceed step by step towards the discovery of truth.

I am well aware that it is no easy task to discard old opinions, imbibed, if I may be allowed the expression, in our youth, from the great luminaries of medicine; but, as soon as their fallacy has been proved, by the intelligence of the age, or by new facts, it then becomes our duty to abandon them, however great the authority from which they may have emanated.

Now upon reviewing the theory of Galen respecting the action of the pulse, it must be observed that the physician of Pergamus, following, as he did, the pneumatic doctrine, necessarily adopted erroneous and arbitrary opinions. First, he says that the mechanism of the pulse consists in the alternate contraction and dilatation of the arteries, and that this oscillatory motion is owing to the absolute power which, according to him, the tunics possess, of exercising it independently of the stimulus of the blood. According to Galen, the vital powers alone effect the contractions of the heart; and it is the heart, in his opinion,

which, by means of the pneuma, communicates the same power to the arteries.

The influence of the authority of Galen over the too-easy credulity of his successors was another prejudice which misled them so far as to induce them to adopt, partially if not wholly, his ideas concerning the mechanism of the pulse, and what is worse, these ideas were prevalent in the last century, and still predominate to the present day, although divested of the pneumatic principle. Two reasons may be adduced to prove that Galen's theory should not have so much weight in the present question: firstly, because Galen erroneously confounds the power with the act of the arterial contraction. It is true, the arteries have the intrinsic faculty of contracting and dilating themselves; but, notwithstanding this, they cannot perform their contractions and dilations without the assistance of an agent which sets the power in motion: the power, therefore, and not the act of contracting, is intrinsic. In the second place, Galen's theory upon the mechanism of the pulse cannot be maintained, because he attributes to a chimerical being, such as the pneuma is, the action which belongs solely to the blood, of setting in motion or exercise the intrinsic power which the heart

and arteries possess of oscillating. But, notwithstanding this, Galen's ideas, as I have already observed, upon the mechanism and the cause of the pulse, though somewhat modified, still find supporters.

Dumas, indeed, differs but little from Galen upon this subject, as that otherwise-eminent physiologist likewise makes the exercise of the pulse to consist in the alternation of the contractions and dilatations of the arteries, an alternation which he considers the same as an intrinsic property of their tunics, entirely independent of the impulse or stimulus of the blood, and of the contractions of the heart ; with this difference, that Galen admits the existence of the *pneuma*, of which Dumas justly makes no mention ; and that the former asserts that the arteries are dilated, because the blood penetrates into them, while the latter says that the blood penetrates into them, because they are dilated. These are nearly his words. “ *La propriété générale des vaisseaux artériels, d'être alternativement contractés et dilatés, constituent ce que les médecins appellent le pouls.*” * “ *Il est impossible,*” says the same writer “ *de revoquer en doute l'ac-*

* See Dumas, *Op. cit.* Tom. ii. p. 440.

“ tativité des artères dans les contractions et les
 “ dilatations alternatives qu’elles produisent,
 “ si l’on réfléchit au but et à la fin de ce double
 “ mouvement. Car puisqu’elles doivent rece-
 “ voir le sang, elles se disposent à la récep-
 “ tion de ce fluide, par le mouvement qui les
 “ dilate et les ouvre ; elles le chassent ensuite
 “ par celui qui les contracte et les referme.
 “ Dès-lors elles agissent avant que le sang
 “ entre dans leurs cavités ; elles s’y prêtent
 “ d’elles-mêmes, et ce n’est point, comme di-
 “ sait Galien, parce que le sang y pénètre
 “ qu’elles sont dilatées, mais plutôt le sang y
 “ pénètre, parce qu’elles se dilatent.”*

Hence, from all that we have hitherto said,
 it clearly appears that Galen and Dumas have
 both erred in confounding the power with the
 act of pulsation in the arteries ; since the
 power which these possess, of contracting and
 dilating themselves, whilst it resides in the
 union of the contractility and tonicity of their
 tunics, differs likewise in fact from the exer-
 cise of their contractions ; contractions with
 which the specific stimulus of the red blood,
 which sets the power in motion, necessarily
 concurr. Tonicity and contractility, and not

* Dumas, *Op. cit.* Tom. ii. p. 431.

the contractions and dilatations, are therefore the intrinsic properties of the arterial tunics, and these latter, at most, represent the product of the vitality of the arteries, and of the stimulus of the red blood, which acts specifically upon them, and produces with another agent what is termed by physicians the pulse.

“The beating of an artery,” says the learned physiologist Jacopi, “is not derived from a particular property of that vessel called by Galen *pulsifica*. Rosa, Scarpa, and several others, have frequently observed that a small gut, placed in communication with a large artery of an animal (as is practised in the celebrated experiment of the transfusion of blood), pulsates like the artery itself: the latter, therefore, is not less passive than the gut in pulsating.”* Whilst we avail ourselves of the authority of this learned physiologist, for the purpose of demonstrating the erroneousness of the theory of Galen and Dumas, who imagined that oscillation was an intrinsic property of the arteries, we would have it observed that the above-mentioned gut, being unendowed with tonicity or sensibility,

* See Jacopi, Elem. di Not. e di Fisiol. comp. Tom. i. p. 206.

cannot pulsate, like an artery, by elasticity alone. The chords of a violin, it is true, oscillate by virtue of their natural elasticity; but it cannot be affirmed that they therefore oscillate as the arteries do. The experiment to which we allude, is also, in our opinion, decisive, as it clearly proves that the power, and not the act of pulsation, is inherent in the organization of the arteries.

Albert Haller coincides, to a certain degree, with the view taken by Galen and Dumas of the mechanism of the pulse. That physiologist places the oscillations of the pulse in the dilatations of the artery, and makes it to consist in the exercise of the alternation of its contractions and dilatations, without taking into account, or even mentioning, either the stimulus of the blood, or the action of the heart. Such at least is the sense in which we must understand him, when he says: “*Mihi quidem de phenomeno ipso dubium nullum superest. Etsi enim utique non rarum est in vivo animale inciso pulsum nullum apparere, neque videri arterias dilatari, tamen frequentes satis observationes sunt, utique dilatationem et oculis et tangentis digito fuisse manifestam, ut arteriæ arcum majorem describant, dum dilatantur.*”*

* See Haller, Op. cit. Tom. ii. p. 238.

Again he adds, in another place of his work upon physiology: “ *Hæc alterna arteriarum micatio est, quam medici pulsum vocarunt, quo nomine dilatatio quidem arteriæ potissimum intelligitur.*”* It is only in his Mémoires, where Haller treats of the motion of the blood, that he makes mention of the heart, and of the action of the blood. He there expresses himself as follows. “ D’abord je me suis assuré que
 “ le sang, poussé par le cœur, dilate les ar-
 “ tères, et forme ce battement qu’on appelle
 “ le pouls.” We shall show, in the proper place, that if the dilatations of the arteries are oftentimes perceptible by the eye, and sensible to the touch, according to Haller’s observations, they are so to the eye by the concurrence of certain causes which are wholly accessory, and to the touch, not because, as Haller thought, the arteries dilate themselves in a great degree, but on account of the presence of another agent, foreign to their functions.

Bichat differs from the above-mentioned opinions upon the mechanism of the pulse. This anatomist, being unable to discover with his eye the dilatations of the arteries of different living animals, although he had with the greatest

* See Haller, Op. cit. lib. vi. p. 242.

skill removed every accessory part, inferred, from this circumstance, that it was erroneous to suppose that the dilatation of the arteries gave rise to the beating of the pulse; and finding, on the contrary, that a certain locomotive motion was observable in them, instead of that of dilatation, he thence concluded, that the whole mechanism of the pulse consists in the locomotive motion, which is there effected, in his opinion, by virtue of the systole of the heart; the latter being, according to him, the special agent of the arterial contractions; for, Bichat firmly believed that the arteries are completely passive in their beating. “ Il me reste,” says he, “ à examiner comment le cœur produit le
“ pouls par ce mouvement brusque et instan-
“ tané. Or, nous avons encore sur ce point
“ beaucoup d’obscurité à éclaircir; mais on ne
“ sauroit disconvenir que la locomotion du
“ système artériel ne soit pour beaucoup dans
“ ce phénomène. A l’instant où la masse san-
“ guine est poussée ainsi du cœur vers les ex-
“ trémités par un mouvement de totalité, pour
“ ainsi dire, elle tend inévitablement à redres-
“ ser les artères, surtout quand elles sont
“ flexueuses. Ce redressement y détermine
“ nécessairement une locomotion, laquelle pro-
“ duit le battement de l’artère. Quant à la

“ dilatation,” he continues, “ elle est presque
 “ nulle dans l’état ordinaire.” He then con-
 cludes thus: “ La dilatation et le resserrement
 “ des artères étant peu de chose, et même
 “ presque nul dans l’état ordinaire, il paroît
 “ que la cause spéciale du pouls est, comme
 “ l’a très-bien observé Weitbreck, dans la lo-
 “ comotion des artères, locomotion qui est
 “ générale et instantanée pour tout leur sys-
 “ tème, et non point consécutive comme cet
 “ auteur l’a entendu.” *

But, if the locomotive motion of the artery does in reality produce the beating of the pulse, as Bichat pretends, such a motion should at least be general and constant; which is not the case, as proved by his own experiments. “ En effet,” says Bichat, “ la direc-
 “ tion varie dans les troncs et les branches.
 “ Lorsque les troncs des artères, tels que les
 “ carotides, les iliaques primitives et abdomi-
 “ nales, sont mis à nu sur un animal vivant,
 “ on n’y voit en effet aucune espèce de loco-
 “ motion, comme là où les courbures sont
 “ très-marquées. Il y a cependant quelques
 “ exceptions à cette règle pour la direction

* See Bichat, An. gén. Tom. ii. p. 335, 336 and 338.

“ des troncs ; la crosse de l'aorte en est un
“ exemple, comme encore la carotide interne
“ qui offre des nombreuses courbures, qu'on
“ croit faussement nécessaires pour que le
“ choc du sang ne produise point de dérangement dans la substance délicate du cerveau.
“ Plus flexueuse dans les branches, cette direction donne lieu à la locomotion artérielle
“ qui constitue presque exclusivement le pouls,
“ selon beaucoup de médecins.”*

But even if it is conceded that the locomotive motion be constant and general in the arterial vessels, although it be not conformable with the almost circular direction of the fibres of the proper tunic of the arteries ; it does not necessarily follow that such a locomotive motion occasions the beating of the pulse : for, in order that this may take place, it is necessary that the artery exercise its reciprocal motion of systole and diastole ; and if this were not the case, there would be observable, under the fingers, a species of arterial undulation, or waving, instead of the beating, properly so called. This trembling, or longitudinal motion of the arteries, has nothing in common with their pulsations. The evidence of this fact

* See Bichat, An. gén. Tom. ii. p. 266.

was not disputed by the ingenious and worthy Bichat, who, notwithstanding his own opinion that the locomotive motion of the arteries gives rise to their beating, confesses that that of their dilatation also contributes to it, as appears by the following quotation from his work.

“ Quant à la dilatation de l'artère, elle est
 “ presque nulle dans l'état ordinaire; cepen-
 “ dant si vous appuyez un peu sur l'artère, le
 “ sang fait effort pour la dilater, et cet effort
 “ augmente le sentiment du pouls. Jadelot
 “ a cru même qu'il le constituoit seul.”*

On the other hand, Bichat himself, were he now amongst us, could not but admit the systole and diastole of the arteries, an alternate motion which does in fact take place there, although it be not, unless very seldom, perceptible by the eye, and this for secondary causes, as will hereafter be shown. “ Il est
 “ assez difficile,” says Dumas in his work already quoted, “ de constater la dilatation par
 “ expérience. Cependant il y a des portions
 “ du système artériel où les yeux peuvent ai-
 “ sément le saisir, comme la crosse de l'aorte,
 “ les carotides, par exemple, qui se dilatent
 “ évidemment lorsqu'elles reçoivent le sang

* See Bichat, An. gén. Tom. ii. p. 336.

“ du cœur.”* In order, however, to prove that the systole and diastole of the arteries take part in the beating of the pulse, it is not necessary to see them contract and dilate; it is sufficient merely to feel their beating with the fingers. It also results from experiments tried upon various living animals, that whilst the locomotive motion is not constant, but only occasionally and accidentally observed along the arteries, their beating, on the contrary, never fails to make itself perceptible by the fingers, when not even the least locomotive motion takes place in the arteries, laid bare and cleared of all the adjacent parts; a circumstance which ought not to exist. In this state of things, it appears to us expedient to continue our researches still further, in order to ascertain whether the locomotive motion has really any thing to do with the exercise of the pulse, and to what extent it actually participates in that of dilatation.

The learned physiologist Soemmerring attributes the beating of the pulse to various causes. He firmly believes that the exercise of the pulse is produced by the longitudinal motion, and by the dilatation and locomotion of

* See Dumas, *Op. cit.* Tom. ii. p. 440.

the arteries: but his opinion appears little conformable with the truth: because, in the first place, he supposes that the arteries can effect three movements, which is not possible, since nature never multiplies agents unnecessarily; and in the second, because the longitudinal motion is not reconcileable with that of dilatation, each opposing the other: we have elsewhere shown that the locomotive motion has not any influence upon the beating of the pulse; neither therefore should the longitudinal motion, which nearly resembles, if it be not identical with it. But it is the obscure dilatation of the arteries alone which contributes to the mechanism of the pulse. Soemmerring, treating of the beating of the arteries, expresses himself as follows:

“ *In corpore vivo arteriæ nunquam non sanguine e corde expulso repletæ sunt, sed alio tempore magis, alio minus turgent. Ubi nimirum arteriæ sanguini, qui a vi cordis undatim intro pellitur, et illarum premit parietes, cedunt, supra mediam diametrum manifesto in longum et transversum extenduntur: hic proximo temporis momento vis cordis remittitur, arteria tum in longitudinem, tum, et apertius quidem, in transversum, partim vi sua elastica, partim propria vi vitali contrahitur, et infra mediam diametrum imminui-*

tur, atque ita plus quoque sanguinis, quam supra mediam acceperat diametrum, protendit; deinde denuo relaxatur, et novæ sanguinis undæ locum concedit.

“ *Præter has in arteriis magnis tactui et quandoque visui obvias mutationes in partibus, quibus laxæ arteriæ adhærent, simul fit ut, præcipue si distentioni non facile cedunt, loco moveantur. Id omne pulsum vocant, ictum, pulsationem vel micantem arteriarum motum.*”* Thus it appears to us that Soemmerring’s opinion upon the mechanism of the pulse falls to the ground, as soon as the triple motion of the arteries is found to be no longer necessary, as he believes it to be, to the exercise of the pulse, in which also another agent is concerned, of which he makes no mention.

The learned professor Richerand attributes the exercise of the pulse to the motion of the dilatations of the arteries, and the mechanism of its beating to the increase of their diameter; an increase arising, he says, from the impulse of the blood, which is effected by means of the systole of the left ventricle of the heart. We shall give his explanation of this pheno-

* See Soemmerring, *De Corp. human. fabric.* Tom. v. p. 84 & 85, *Physiolog. Puls. et Causæ Pulsus.*

menon in his own words: “ Comme les artères sont toujours pleines durant la vie, et que le sang y coule avec d’autant moins de rapidité, qu’elles sont plus éloignées du cœur, la portion de ce fluide, que les contractions du ventricule gauche poussent dans l’aorte, rencontrant les colonnes antécédentes, leur communique l’impulsion qu’il a reçue; mais retardé dans sa marche directe, par la résistance qu’elles lui opposent, il agit contre les parois des vaisseaux, et les écarte de leur axe. Cette action latérale, par laquelle les artères sont dilatées, dépend donc de ce que leurs cavités sont toujours remplies par un fluide qui résiste à celui que le cœur projette. Plus considérable dans les grandes artères que dans celles d’un moindre calibre, cette dilatation se manifeste par un battement connu sous le nom de pouls.”* He then thinks with Lamure, that a slight movement or shock, which occurs in the arteries during their dilatation, may also contribute in the second place to the beating of the pulse. “ Les expériences de Lamure,” he adds, “ autorisent à croire qu’une seconde cause du

* See Richerand, *Elém. de Physiolog.* Tom. i. p. 319.

“ poulx est un léger déplacement que les
“ artères éprouvent en même temps qu’elles
“ se dilatent.”

Richerand’s opinion upon the beating of the pulse coincides with that of Dr. Serrurier, who, in the Dictionary of the Medical Sciences, says, in the article POULX: “ Or, le poulx est donc
“ le mouvement latéral par lequel le sang tend
“ à se porter vers les parois de l’artère en
“ s’écartant de son axe.”

We allow that the systole of the left ventricle is the first spring which drives the blood with impetus into the aorta; but we cannot with any foundation admit that the impulse of the blood alone, without the concurrence of another agent, is sufficient to occasion the beating of the pulse. The truth is, that it does not yet appear from experiments, that the arteries, of whatever calibre, when disengaged from all their accessory and adjacent parts, give to the eye, although provided with a powerful lens, the least sign of the consequent dilatation by the systole of the left ventricle of the heart, as was thought to be the case by Richerand and so many other physiologists. But whilst the arteries give not the least sign of dilatation to the eye, as we shall see, they do not, however, cease to beat and

oscillate, when compressed by the practitioner's fingers, a circumstance which clearly shows that the exercise of the pulse is not the direct consequence, or natural effect of their contraction and dilatation, or of the impulse of the blood occasioned by the systole of the left ventricle of the heart.

Among our own countrymen, also, the opinion generally prevails, that the mechanism of the pulse consists in the dilatation of the arteries, or, which is the same thing, that it is to be referred to the alternate motions of their contractions and dilatations. Thus the worthy Domenico Cirillo observes: “*Pulsus itaque dicitur alternus arteriæ motus, quo scilicet diversa dilatatio semper contractioni respondet, atque secundum varia vitæ, et corporis accidentia mutatur arteriarum assidua dilatatio.*”*

Jacopi, formerly professor of anatomy and comparative physiology in the university of Pavia, in his work already quoted, treats of the subject of the pulse, and thus explains its mechanism. “The blood,” says he, “which runs uninterruptedly through the arteries, becomes more rapid under the consecutive compressions of the heart and arterial vessels : this

* See Cirillo, Tract. *de Pulsibus*.

sanguineous wave, upon which the heart has an immediate action, driven by the force of that organ into the aorta, proceeds with a strong impetus to dash itself against the wave which has preceded it, and which, being thus stricken, cannot but likewise impinge upon the one before it, and thus successively the sanguineous wave which is found in the aorta resists that which is on its way thither, whilst the latter encounters resistance from the anterior one, and this because the velocity of the blood decreases considerably as it removes from the heart; being, therefore, compressed both before and behind, it cannot but compress and dilate the artery, which lateral compression and dilatation taking place, so to speak, instantaneously, and with a smart blow, the beating becomes perceptible, and is properly that which we call the pulse.”*

Such likewise is the opinion most general among the learned writers and physicians of this capital upon the mechanism and causes of the pulse; for they refer both these phenomena to the increase of the diameter of the artery, or to its dilatation. “The increase of the artery,” says John Hunter, “is so ma-

* See Jacopi, *Op. cit.* Tom. i. p. 208 and 209.

nifest, as to be felt or seen, and produces what is called the pulse :”* which is equivalent to saying, that the increase of the artery, which does not differ from that of its dilatation, is so sensible to the touch and to the eye, as to be sufficient, in his opinion, to give rise to what is commonly called the pulse.

Nor do the opinions of many of Hunter’s countrymen, still living, upon this subject, appear to differ materially from his ; for the writer of the article upon the circulation of the blood, in Rees’s new Cyclopædia, advances the same theory, in different terms. He admits the diastole of the arteries, which, according to him, arises from the lateral pressure of the blood forcibly driven into those canals. “ We admit,” says he, “ a diastole of the arteries, arising from the lateral pressure of the blood forcibly projected into these canals :” he also makes its mechanism to consist in the dilatations and successive contractions of the arteries, in consequence of the successive impulses communicated to the blood along the arteries by the repeated contractions of the heart, and by their own powers, of which one, he says, is muscular, and the other elastic.

* See Hunter, *Op. cit.* p. 309.

He expresses himself in these terms. “ The pulse is well known to consist of the successive dilatations and contractions of the arteries, in consequence of the successive impulses given to the blood through them by the repeated contractions of the heart, and by their own muscular and elastic powers.”

From what has been advanced upon the mechanism and causes of the pulse, it appears that almost all the most distinguished physiologists of Europe, as well as the majority of our contemporaries, have made, and still make, its mechanism to consist, either in the alternation of the contraction and dilatation of the arteries ; in their longitudinal motion or locomotive movement ; in the lateral motion of their parietes ; or finally, as asserted by Soemmerring, in the combination of all these three movements. Such at least are, in abstract, the opinions which may be gathered from an examination of their works upon the circulation of the blood, and the pulse ; opinions, which all originate, if I mistake not, in the deduction which induced these writers to believe that the before-mentioned movements, of locomotion, dilatation, &c., could actually take place in the arteries, because they are sometimes, from secondary or accidental causes,

observed in the arteries of living animals, laid bare, divided from their adjacent parts, and denuded so as to make their movements perceptible by the eye. In fact, Dumas, having observed the dilatation of the arc of the aorta and of the carotidæ, concluded from that circumstance, that a similar movement of dilatation was the cause of the pulse. Bichat, also, because he saw that a certain kind of locomotion was propagated along the tortuous arteries of certain animals, erroneously concluded therefrom, that such a locomotion must be the cause of the pulse &c.

The fact is, that the above-mentioned motions, as well as others, which at various times may have been observed in the arteries of living animals, after those vessels have been disengaged from all their adjoining parts, must all have been precarious or accidental: for, first, it does not follow, that because the circulation of the blood performs its course, and the pulse exercises its beatings, the arteries have either the movement of dilatation or the locomotive motion; secondly, neither is it necessary, that because the mechanism of the pulse takes place, the dilatation of the arteries should be sensible to the sight, or so evident as the majority of physiologists wish it to be. This

observation will appear the more reasonable, if we consider that all the motions which are attributed to the arteries, and which are sometimes observed in them, may be, and often are, found wanting in the arteries of living animals ; whilst it is merely necessary to press the said arteries with the fingers, to feel their beating and oscillation, notwithstanding that they do not give to the eye the least appearance of motion.

In support of what has been advanced, we have only to appeal to the numerous and decisive experiments made by Dr. Parry upon the carotidæ, the aorta, and the femoral arteries of a great number of sheep, rabbits, dogs, horses, and various other quadrupeds ; because, in the greater part of his experiments, as he himself candidly acknowledges in his quoted work, he did not observe the least movement of any kind caused by the systole of the left ventricle of the heart. He adds that it is only from some secondary or accidental causes that the oscillation of the carotids, and of other arteries of similar calibre, can be perceptible, after these vessels have been cleared of the contiguous parts, according to the usual method adopted in these cases. The secondary or accidental causes to which Dr. Parry refers

the sensible dilatation of the arteries, or their locomotive movement, are: the compression of the muscles; any irritation of the nervous system; the always agitated and disturbed respiration of animals subjected to these experiments; the accumulation of hard excrements in the colon, and the obstruction which may be found in the abdomen, near to or in contact with the arteries: these, and similar secondary causes, may very easily compress the corresponding arteries, and occasion such a disarrangement or want of equilibrium in the system of the circulation of the blood, as may give rise to any of the three movements of which the arteries, in their natural state, are erroneously supposed to be capable.

We shall here lay before the reader a few from among the many experiments which were performed by Mr. George Norman, in the presence and under the direction of Dr. Parry. Having first detached the carotid arteries of several live sheep and rabbits from their adjacent parts, for the purpose of examining the functions of the sympathetic nerve, and of observing, at the same time, the effect of the ligature, they found, and not without wonder and surprise, that the said arteries, denuded and exposed to their sight, were entirely free

from all motion of dilatation, even in the act of the systole of the left ventricle of the heart; precisely as if these arteries were so many inorganic cylinders: they observed, however, a kind of longitudinal or locomotive motion; and this, it is true, at one time extended and elongated itself in the direction of the thorax, in the short interval of the inspiration of the animal, and at another retrograded during the act of its expiration; so that this locomotive motion of the carotid arteries coincided with the agitated respiration of the animal itself: the experimentalists counted by a watch eighty-four inspirations in the course of the first minute, and as many longitudinal motions; whilst, on the contrary, the same arteries, compressed by the fingers, afforded one hundred and eight beatings in the same space of time: all which evidently proves that this locomotive motion, which sometimes occurs in the arteries of living animals (for Dr. Parry and Mr. Norman have not observed it in various other animals, subjected to the like experiments), does not depend, in the least degree, upon the systole of the left ventricle of the heart, as Bichat and many others assert to be the case: so much the more, as the sheep upon which the experiment was tried, having

ceased to respire, at least for a few seconds, not the smallest locomotive motion was observed, but again showed itself as soon as the animal recommenced breathing; and moreover, what removes all doubt, the exercise of the pulse was never interrupted by the suspension of the said locomotive motion.*

After having demonstrated that the movements of locomotion and of dilatation of the arteries, to which all the others are reducible, are perceptible to the eye by the means of secondary and accidental causes, and not in consequence of the systole of the left ventricle of the heart, it would be blinding ourselves to the clear light of experiment, to continue to admit the most generally-received opinions, that the mechanism of the pulse consists either in the alternation of the contractions and dilatations of the arteries; in their longitudinal or locomotive motion; in the increase of their diameter; or, finally, in the lateral dilatation of their parietes, or, as Soemmerring pretends, in the concurrence of all these motions. We, who have been led to conclude, from the experiments already described, that all the motions alluded to are visible on account of accessory,

* See Parry, *Op. cit.*, p. 102 and 103.

secondary, or accidental causes, and that they are neither general nor constant in the arteries, which beat generally and constantly under the fingers, even when there does not appear the least movement of any kind: we, I repeat, are convinced of the necessity of renouncing the opinions already described upon the mechanism and causes of the pulse: and our rejection of them is in conformity with the just and luminous maxim left us by Roger Bacon, in his classical work, entitled, "*Opus major*:" that of joining experiment to reasoning, when we are desirous of avoiding errors and abuses, and of advancing in the study of nature.

It is a fact well known to all experienced physiologists of the present day, that the arteries are always found to be, and actually are, dilated in the natural state. The uninterrupted gushing out of the blood from the wounded or opened arteries, as well in their contractions as their dilatations, is an evident proof that the arteries are always full of blood, and consequently always dilated, both in systole and diastole. Another proof tending to demonstrate that the arteries are always full of blood, and constantly dilated, arises from our being able to see, with the help of a microscope, the mesenteric arteries of a frog al-

ways full of an aqueous and transparent liquid, which certainly there replaces, if it be not a substitute for blood.

If, therefore, the arteries are always full of blood, and in consequence proportionably dilated in the natural state, no reason can be given why the arteries should become dilated in the beating of the pulse. “*Quelques efforts qu’on fasse,*” says Bichat, “*pour dilater les artères par les injections avec l’eau, l’air, les substances grasses, etc.; elles ne prennent guère un calibre supérieur à celui qui leur est naturel.*”^{*} Now if the arteries do not become dilated by the injection of another fluid, which, being united to the blood, ought to dilate them, or would at least be a reason for our believing that it could do so; how is it possible that this could be effected in the beating of the pulse? The column of blood, also, the diameter of which cannot be augmented or increased in a single instant of time, will not allow us to give credit to the sensible dilatation of the arteries in the natural state.

We admit that the blood circulates with greater impetus in the arterial trunks which are nearer to the heart, and that the sangui-

* Bichat, *Op. cit.* Tom. ii. p. 306.

neous waves which come on, forcibly expelled by the systole of the left ventricle, strike against, press, and thrust forward, the other sanguineous waves, which precede them: but it is not to be thence inferred that the arteries dilate themselves to such a degree as to exceed the limits of their diameter; this effect can only be verified in a state of disease, and a visible proof of it is to be found in aneurisms or arterial tumours.

Hence, without imagining that the arteries become dilated, because they beat and oscillate, it is more natural to say that the arteries react upon the blood which stimulates them, and drives them forward with their invisible and alternate motion of systole and diastole: but this motion of systole and diastole, which the arteries exercise during the state of life, cannot, and ought not to extend beyond the limits of their diameter; otherwise nature would have subjected them to an uninterrupted state of violence, which certainly has not been her wise intention: now the arteries not being able to dilate themselves beyond their diameter, their dilatation cannot consequently be the cause of the beating of the pulse.

This truth, viz., that the dilation of the ar-

teries cannot be the cause of the beating of the pulse, is also confirmed by the daily practice of physicians ; who, it is well known, do not confine themselves to the act of applying the fingers upon the artery, which would certainly suffice, if the arteries dilated themselves as these authors suppose: on the contrary, they search for the artery in order to press it, and by that pressure they discover and feel its beatings. Thus, it is clear, that the whole mechanism of the pulse is reduced to an effort or reaction, which the artery makes in order to resume its natural dimensions, or to regain its former capacity ; because the pressure which the fingers make upon the artery diminishes its capacity ; then, the artery which is forcibly stimulated by the action of the red blood, driven thither with impetus by the systole of the left ventricle of the heart, cannot but react, and this reaction produces and occasions a proportionate resistance against the fingers compressing it. The pulse, therefore, is any thing rather than the natural effect of the sensible dilatation of the arteries : these, in reacting, or in making the effort already mentioned, do not, as is commonly supposed, dilate themselves ; but rather endeavour to regain the natural capacity of which they had

been deprived by the pressure of the fingers in the act of observing the pulse.

The pressure of the fingers, therefore, is the agent which, together with the systole of the left ventricle, the stimulus of the red blood, and the physico-vital powers of the arteries, concurs in the beating of the pulse. This truth enables us to comprehend the reason why the arteries of living animals, after being laid bare, most frequently appear immoveable like so many inorganic cylinders, and free from every kind of motion; whilst; (a circumstance which gives greater weight to the argument, and bears stronger evidence to the truth,) these same arteries, being pressed down by the fingers for the purpose of examination, never fail to exhibit that effort or reaction which is properly called the pulse, and not the longitudinal, locomotive, or lateral motion, nor even that of the dilatation of the arteries, which motions are all accidental, or are thus sensibly perceptible to the observer in the state of disease.

In fact, the sensible dilatation of the arteries takes place when life is in great danger, as happens in the case of inflammatory fevers of the first degree; in these, the diastole, or dilatation of the arteries, can indeed extend itself,

and make itself more observable: a proof of which we find in the fulness and great strength of the pulsations of the temporal arteries at the time of the increase of fevers of this kind: the more so, because the tonicity and contractility of the arterial tunics gradually yield to the violence of the shock of the blood, and a sensible degree of dilatation takes place in those arteries.

The sensible dilatations of the cerebral carotidæ, which are observable in severe cephalalgia, likewise derive their origin from the state of violence of the circulation of the blood; the cerebral carotidæ beat, in similar cases, with equal force: their dilatations are, in fact, so strong, that the ear is sensible of the noise caused by the column of blood, which, beating against the curvature of the osseous canal, shakes and inflames the head, which becomes extremely incommoded at each of their diastoles; hence the immediate cause of the pulsatile pain which is generally experienced by persons labouring under ardent or inflammatory fevers.

But all these morbose phenomena differ *toto cælo* from the natural state of the arteries, which perform their invisible motion of systole and diastole in the circumscribed sphere of their diameter; but they do not, on that ac-

count, become as sensibly dilated in the state of health.

Another series of phenomena, in favour of our view of the subject, is to be found in the observation of organic pulses : these, as will be seen in due time, discover themselves under the form of small eminences, which raise themselves, more or less, upon the horizontal plane of the pulsatile artery ; in such an examination as this, it must be frankly owned, that the arteries sensibly dilate themselves along the track in which the before-mentioned eminences are found ; but never in their natural state. The state of the science certainly requires the mechanism of the pulse to be defined in clear and explicit terms ; but for this purpose we are not to have recourse to our acquaintance with the phenomena which are observed in the arteries, altered, inflamed, or excited, by the action of different diseases, or by other extraneous causes.

It is quite a different thing to examine the mechanism of the pulse in the natural state, where all is the work of nature, and to investigate it in the morbose state, by which its natural character certainly becomes changed : and this is the proper place to observe, that it is precisely the knowledge of the natural mechanism of the pulse, which contributes to the

distinguishing of diseased pulses ; that enables us to discover the real value of the healthy strength of nature ; which affords the rationale of the rules to be observed in examining the pulse, and enables the mind to keep pace with the developement of diagnostic, organic, and critical pulses.

We must also here observe, that Philalethes, a very ancient physician, of whom we have already spoken, in the history of *Sphygmica*, had a remote idea, that the mechanism of the pulse consisted in an effort of the arteries ; for, he says, that its beating is derived at the same time from the shock occasioned by the continual and involuntary motion of the arteries against the fingers, and from the suspension of that shock.

This obscure idea of Philalethes upon the pulse has been improved upon by Jadelot, and better elucidated by Dr. Parry, who has reproduced and developed it, in the clearest manner, in his work already quoted. He also makes the mechanism of the pulse to consist in the effort which the artery makes against the fingers, in order to recover its natural capacity, previously diminished by their pressure in the act of examining the pulse.*

* See Parry, *Op. cit.*, *p.* 111, 112.

We trust that in thus describing the real character of the mechanism of the pulse, we shall be found not to have wandered from the path of truth; at least, such has been our sincere endeavour. Alike insensible to the sophisms, and charms of human reasoning, we have followed, as our sole guides, observation and experiment.

ART. VI.

ANATOMICO-PHYSIOLOGICAL DESCRIPTION OF THE
EXPLORATORY ORGAN OF THE PULSE.

THREE principal things are necessary for fully comprehending the subject of Sphygmica; the first relates to the anatomico-physiological description of the exploratory organ of the pulse, as the instrument upon whose elevation partly depends the skill and ability of the person exercising it; the second respects the mode of educating it conformably with the plan of nature and the rules of art; and the third, or last, regards the caution of never employing it but with the attention requisite, not only for gradually becoming acquainted with the variations, differences, and changes of the pulse, which are so many different expressions of nature, but also for comprehending the true meaning of these her expressions. It is solely to negligence, or to the want of a similar practice, that the abuse of allowing any prejudices to exist against the benefit derived by practical medicine from the doctrine of the pulse, should be attributed.

As to the knowledge of the exploratory

organ of the pulse, every one is aware that it consists in the fingers, in which the organ of touch, properly so called, is most concentrated; I say, properly so called, because the organ of the sensation of touch is diffused over every part of the human machine, in order to its preservation; but it is in the fingers, as I have said, that nature has established its principal seat, and hence they constitute the exploratory instrument of the pulse.

There are, in all, three membranous layers, which cover the external parts of the body; the cuticle, the *rete mucosum*, and the cutis: all these become gradually thinner, as they approach the fingers, for the purpose of covering them, and the fibres from which these layers proceed, are doubtless very thin and delicate: the nervous papillæ with which the cutis of the fingers is furnished, are found there in greater number, and more decidedly pronounced; the cuticle which is the exterior covering of all, is in the greatest degree flexible, fine, and delicate: a kind of mucous humour, which proceeds from the epidermis, moistening the said nervous papillæ, in order to prevent their becoming dry and hard, preserves, in a similar manner,

its natural fineness ; the whole of which apparatus contributes to increase the sensibility of the cutis of the fingers, upon which depends the elevation of the exploratory organ of the pulse. Add to this, the other physical conformation ; viz., that the fingers are composed of various small bones, and are of such muscular strength, as to have the power of extending, contracting, &c., and of performing many other motions peculiar to themselves alone. Now it must be obvious how greatly these physical dispositions contribute to the object intended by nature, that of rendering the fingers extremely mobile and sensible. It is, in fact, to this kind of organization that they are indebted for the power they possess, of examining those bodies which awake in them the sense of touch.

The man who sets but little store by the gifts of nature, has oftentimes reason to complain of not having profited by them. Such is, unfortunately, the case with some practitioners, who, from having neglected to cultivate in time the organ of the touch, cannot, at a later period, succeed in elevating it, when it has become impaired for want of use : under such circumstances, they are unable to distinguish organic pulses in particular, which frequently, indeed, elude the touch of the inexpe-

rienced observer; and instead of referring this circumstance to the want of being well grounded in the exploratory organ, some unjustly attribute the cause to the imperfection of the art, and others to the incapacity of the organ itself; as if man, to use the words of the learned physiologist Fattori, could not elevate himself above human nature by the exercise of his fingers, and by the instrumentality of arts which approach the confines of prodigy. Now it is with the organs of the senses, as with that of the brain, the education, or practice, which instructs, quickens, and perfects them, and decides, at the same time, the degree of capacity to which these organs may be raised.

He who has not his touch and his mind trained to this kind of research, cannot have any acquaintance with the light and rapid changes of the pulse. Dumas, speaking of Fouquet, expresses himself as follows: “Fouquet annonça
 “ quelques espèces (de pouls) dont personne
 “ n’avait traité; et il ajouta aux descrip-
 “ tions déjà données, des caractères secon-
 “ daires fondés sur les changemens que peut
 “ subir la configuration des parois de l’artère;
 “ changemens trop subtils, trop imperceptibles,
 “ trop fugitifs, sans doute, pour des sens vul-
 “ gaires, mais réels, mais appréciables, mais

“ constans peut-être pour un tact favorisé.”*

The touch is certainly improved by its education; and when this is not the case, the attempt to discover the light, rapid, deep, and obscure changes of the beatings of the pulse will be useless. Thus much is certain, that the sense of touch is susceptible of being improved in man alone, on account of the elevation and perfection of its structure.

It must, in fact, be allowed that all other animals yield to man the superiority of the organ of touch: for it appears clear, from comparative anatomy, that not only the tissue of which the corium, or mucous and cuticular membranes of the integuments of animals is made, is coarse and large; but they also have not the organ in question so delicately constructed as it is in man. The prehensile tail of many species of the ape, the muzzle of quadrupeds, the proboscis of elephants, the tail of the beaver, the comb of several species of birds, the lips of reptiles having feet, the beards of fishes, the antennæ of polypi, all the organs of touch, in these different animals, are too coarse to have any pretension to compete, in finish and delicacy, with the same organ of

* See Dumas; Op. cit. Tom. ii. p. 447.

man: it will be obvious, upon a comparative view of the organs of touch in man and other animals, how much better adapted the fingers are for the examination of bodies of every kind, and for the performance of so many difficult operations, as we shall observe further on.

The perfection of man's organ of touch consists, however, in the degree of sensibility of the nervous papillæ, proportioned to the character and physical state of the organ itself; when the sensibility of the nervous papillæ is excessive, pain, or a disagreeable sensation, is then produced, similar to that which results from the too-great sensibility which occurs in the state of inflammation; and when, for an opposite reason, the sensibility becomes weakened by the callosity and hardness of the integuments, or by the want of exercise of the organ itself, in both cases, the inconvenience follows, that the sensations of the touch are obscure and confused, and consequently inefficacious. The perfection, therefore, of the organ of touch is (as already observed,) to be found in the just degree of sensibility of the nervous papillæ, and in that disposition of parts required by the physical state of the organ. To this must be added the other condition, that no obstacle or impediment of any

kind whatsoever be opposed to the free relations which unite the organ of touch with the common sensorium, and that the latter especially be not affected, injured, or reduced to a state of inaction ; for, in such cases, either the sensations do not manifest themselves to the tact, or they do so in a confused and irregular manner, as is observed in apoplexy, mental alienation, sleep, abstraction, &c. &c.

Now, for the purpose of examining the pulse, in order to distinguish the variations, differences, irregularities, and all the other alterations which are usually observed in a state of disease ; it is necessary to educate the exploratory organ of the pulse, before proceeding to this examination ; otherwise, the sensations of the touch, which the artery would communicate to it in the different diseases, would all be reduced to a few ; to that of the great and small pulse, the strong and weak pulse, the hard and soft pulse, the quick and slow pulse, the frequent and rare pulse, and the equal and unequal pulse, as happens when the organ of touch of the observer has not received the requisite education. “ J'avoue,” says Dumas, “ que quand il faut discerner dans la “ pratique toutes les variétés de pouls que les “ auteurs modernes représentent, on est sou-

“ vent arrêté faute d'exercice ; et l'on se trouve
 “ quelquefois obligé de s'en tenir à une simple
 “ apparence.”* Frederic Hoffmann alludes
 to this fallacious appearance, when he says :
 “ *Mirandum certe est, nostros medicinæ prac-*
ticos ad ægrorum lectos accedentes pro more
tantum pulsum contrectare tam levi brachio, ut
vis duos ictus expectent, quum tamen sæpenumero
post decem, aut ultra vibrationes inæqualitas, vel
intermissio demum percipiatur.”†

If it be required to observe, feel, and distinguish the different changes of the pulse with clearness and discernment, the common sensibility of the organ of touch will certainly not be sufficient, even admitting that it is extremely well formed and organized. In order that the result of the examination of the pulse may correspond with its object in any disease whatever, three conditions are necessary ; these are : 1. The education of the exploratory organ ; 2. Skill in the art ; and, 3. and lastly : The attention of the observer.

The education of the exploratory organ of the pulse is effected, in the first place, by preserving and improving, on the one hand, the

* See Dumas, Op. cit. Tom. ii. p. 447.

† See Hoffman, Medic. rational. Tom. iii. p. 162.

softness, flexibility, and fineness of the integuments of the fingers, and by endeavouring, on the other, to elevate, gradually quicken, and educate it by dint of exercise. “ Pour obtenir
“ d’ailleurs des succès dans cette partie du
“ pronostic,” judiciously observes Dr. Pinel,
“ il faut entretenir l’organe du tact dans une
“ délicatesse extrême, et l’exercer, par une
“ culture assidue, à saisir les différences les
“ plus déliées du pouls, dans l’état de santé
“ comme dans celui de maladie.”* That the organ of touch is moreover capable of education, is proved every day.

It is not a rare circumstance to see persons born blind, who, having exercised themselves in judging of the external superficies of different bodies, generally succeed in distinguishing, by means of the touch alone, money, and even colours themselves.

How much more easy, then, must it be to familiarize the organ of touch with the different beatings of the pulse ! Besides, the beatings of the artery are equivalent to so many smart shocks, which produce a forcible impression upon the fingers ; and these shocks have the power of making their various modes of beating

* See Pinel, *Op. cit.* Tom. i. p. lxxxi.

sensible to the organ of touch; besides, the superficies of coins, and of coloured bodies, have no motion, and yet their varieties are easily perceptible by the fingers: add to which another observation; viz., that it belongs to the organ of the pulse to feel and distinguish the arterial oscillations, but not to discern one coin from another, and much less different colours; and although all sensations may be reduced to those of the touch, it is nevertheless a wonderful instance of human industry, to see that the organ of the touch, by dint of practice, appropriates to itself, with impunity, the attributes of the eyes.

But, the callosity and hardness of the fingers strongly oppose the education of the touch; these, while they hinder the nervous papillæ from feeling, diminish the sensibility by their hard and rugged contact. Players on stringed and wind instruments, as well as those persons who employ their hands in any coarse work, all prevent, by such employments, the improvement of the organ of touch; nor can they expect to acquire that degree of skill which is requisite in order to exercise the sphygmical art with credit and success.

The other means of educating the organ of touch is by accustoming it to the rhythmi

and beatings of the pulse in the double state of health and of disease, and in the different periods of life ; familiarizing it also gradually with the changes of the pulse, proceeding from those which are most sensible, to those which are less so ; and finally, improving its acuteness, by exercising it upon the pulses of individuals of either sex, and of different ages, especially when these persons are affected by diseases of various kinds ; the changes and variations of the pulse will then be more perceptible, and consequently their difference more easily discovered by the organ of touch.

“ *Qua enim ratione,*” observes Dr. Sachero, “ *expertus musices magister aures ad minimas quaslibet vocum dissonantias percipiendas sensim accommodat : qua ratione cæcus tactum eo acuit, ut colores ipsos distinguat, ita seria mentis contentione, et frequenti exploratione digitos singulis pulsuum modificationibus discriminandis vel tyro medicus tandem assuescet.*” * “ Telle est, en “ effet,” says the immortal Bichat, “ dans “ nos usages actuels, la nature de nos occu- “ pations, que celle à laquelle nous nous li- “ vrons habituellement exerce presque tou- “ jours un de ces organes plus particulière-

* See Sachero, Op. cit. p. 25 and 26.

“ ment que tous les autres. L’oreille chez le
 “ musicien, le palais chez le cuisinier, le cer-
 “ veau chez le philosophe, les muscles chez le
 “ danseur, le larynx chez le chanteur, etc.;
 “ ont, outre l’éducation générale de la vie
 “ extérieure, une éducation particulière, que
 “ le fréquent exercice perfectionne singulière-
 “ ment.”*

In the second place, a skill in the sphygmical art, so necessary to the successful practice of medicine, is to be acquired by first studying and reflecting upon the most esteemed works on the subject, such as the treatises upon the pulse, published by Galen, Sthrutius, Solano, Nihell, Borden, Gandini, Cox, Fouquet, Cirillo, and other famous physicians, and by attentively repeating at the bed-side of the sick the observations and researches they have left us in their works as our guides; by thus repeating them upon various patients of some large hospital, the student succeeds in gaining a slight acquaintance with the language of nature: and by dint of these repetitions upon fresh patients, afflicted with diseases of a different kind, he eventually acquires

* See Bichat, *Rech. physiol. sur la vie et la mort*, p. 121 et 122.

that familiarity with the modifications and changes of the pulse, which at length makes him an adept in the art.

The tyro, who thus exercises himself in examining the pulses of so many patients of every class, order, kind, or species, proceeds from error to error, from effort to effort, and from reason to reason, to the acquirement of the science. And who is ignorant of the fact, that errors and efforts are the parents of great truths? while the mind of the young practitioner is thus developing itself, and advancing in knowledge, by following the path of observation, the organ of touch receives, at the same time, the advantage of elevating, sharpening, and gradually educating itself; and thus, by slow degrees, as is the fate of all human affairs, he at length becomes versed and skilled in the science of the pulse, nor fears to encounter the dangers and difficulties, and even the long and painful effects of the multiplied researches to which he must devote himself.

Finally, attention contributes to the education of the organ of touch, and to the skill of the observer, when this faculty of the mind is, in the greatest possible degree, present at every observation of the pulse; with the stimulus and assistance of the attention, it is not

difficult to seize and distinguish the variations of the pulse in a state of disease. The attention which puts the fibres of the cerebral organ into a certain orgasm, or into greater activity, considerably increases the sensibility of the nervous papillæ of the organ of touch, both organs being in a state of mutual dependence; and by this means the attention increases the power of the exploratory organ of the pulse. In other words, the attention raises, stimulates, and gives a shock to the nervous fibres of the brain and of the sensorial organs, and consequently, by rendering them more energetic, increases their susceptibility: and it is precisely this mechanism which improves the power, activity, and energy of the exploratory organ of the pulse in the course of the exercise of its functions. In short, every thing concurs in proving that the above-mentioned faculty of the mind causes the sensibility of the organ of touch to be concentrated in the points of the fingers; and the organ of touch being thus concentrated, securely acquires, in this situation, that exquisiteness of feeling, which enables it to distinguish every light, rapid, and obscure beating of the pulse; so great an influence has the attention upon the acuteness and perfection of the sensorial organs.

But besides the education of the mind, and of the organ of touch, a requisite so necessary to every person who is desirous of entering upon the study of the science of the pulse, it is likewise indispensable to be acquainted with certain rules, which should be religiously adhered to in the observation of the pulse.

OF THE RULES TO BE PRACTISED IN THE CORRECT
OBSERVATION OF THE PULSE.

The first rule which is requisite for a correct observation of the pulse, consists in the precaution to be taken, in order that the temperature of the observer's hand be neither too low nor too high; for if it be too low, the temperature of the patient must appear very high, whilst such is not actually the case, or at least cannot be to such a degree as it apparently is; on the contrary, if the temperature of the fingers be too high, that of the patient must appear low or moderate, whilst in reality it is not so.

And the rule for knowing and estimating the just degree of temperature of the patient's body is of no small advantage in febrile disorders, not because we admit the erroneous opinion of Galen, who limited the essence of the fever to the unnatural increase of the ani-

mal heat; but rather, because it appears to us to be the animal caloric, excessively concentrated in the common integuments, and in the internal organs of those suffering under fevers, the index of orgasm, or a general disturbance, or the sign of the state of prostration of the vital powers. “*In caliditate præter naturam,*” says Galen, “*maxime quidem in totum animal effusa, sin minus, et omnino vel in pluribus partibus, vel in nobilissimis accensa, consistit febris.*”*

This opinion, however, of Galen, cannot be correct; since, in various cases of fevers of malignant character, the patients appear cool, and without any unnatural increase of caloric, although their life be in great danger, and the fever which is accustomed to assume this disguised form is threatening. In all cases, the rule for appreciating the state of the height or depression of the patient's temperature is, as before observed, of great utility, whatever may be the disease, because the degree of the animal temperature influences the character of the pulse, and its just degree cannot be estimated, when the temperature of the observer's fingers is not moderate.

The second rule is not to observe the pulse

* See Galen, *de Febris*.

immediately upon entering the patient's room, and before ascertaining the tranquil state of his mind, which generally corresponds with his physiognomy. The presence of the physician, which produces a stimulus upon the physical and moral system of the patient, excites the motions of the heart and arteries, and increases the energy of the pulse to such a degree, that it becomes in appearance febrile; and this acceleration of the pulse is more or less perceptible, and proportioned to the degree of confidence which the physician inspires, especially with young females, which caused Haller to remark, "*Medici præsentia in tenerioribus feminis arterias frequentius agitare.*"* Such being the case, it would be in vain for the physician to expect to ascertain the true state of the patient, by means of the pulse, without observing the rule of examining it some minutes after his arrival in the patient's chamber.

Thus, if it happen, as it frequently does, that the mind of the patient is agitated by some passion; the first object must be to tranquillize it by suitable reasonings, always deferring the examination of the pulse till the

* Haller, Op. cit. p. 252.

moment the agitation has ceased; otherwise it is not necessary to depend on the signs, then obscure and fallacious, of the pulse, or the risk of deceiving himself, which the physician runs, by wishing, notwithstanding, to give his opinion upon the real state of the patient, is certainly great. The whole nervous system is in orgasm when any passion whatsoever acts upon, agitates, or affects the mind of the patient; and hence necessarily follows the alteration of the course of the blood, and of the beatings of the pulse. The importance of this rule becomes likewise more confirmed by the following opinion of Celsus; "*Ob quam causam,*" he says, "*periti medici est, non protinus ut venit, apprehendere manu brachium, sed primum residere hilari vultu, percunctarique, quemadmodum se habeat, et si quis ejus metus est, cum probabili sermone lenire, tum deinde ejus carpo manum admove.*"*

The third rule respects the number of the bedclothes, and the manner in which the patient is found covered in bed; because, in proportion to this circumstance, the temperature of the body is heightened or lowered; and this temperature, which we call artificial or acci-

* See Celsus, Op. omn. Lib. iii. p. 343.

dental, has nothing to do with the animal heat properly so called, which is regulated by the state of the circulation, respiration, and of all the other functions of internal life: and whilst the former temperature is altogether accidental, it nevertheless contributes to the elevation of the natural temperature of the patient's body, and with this accelerates the course of the blood, and consequently the beatings of the pulse: on the contrary, we are always sure of finding the temperature of the patient low, and hence a slackening of the course of the blood, and of the beatings of the pulse, when he is not properly covered in bed. The difference of temperature in patients, arising from the effect of the bedclothes, is so sensible, that it is not a rare occurrence to see the artificial heat and the acceleration of the beating of the pulse diminished, by taking off the load of superfluous blankets, &c.

The fourth rule regards the position in which the patient should be placed in bed, at the moment of observing his pulse. In general, the posture of the trunk, the arms, and the hands, should present no obstacle to the free circulation of the blood, nor offer any stimulus to its acceleration: the true medium will be observed, when the patient is laid upon his

back, with his head a little raised, and lying upon the bolster, when his whole body makes not the least exertion, and when his arms and hands are free in the sleeves of his shirt, and entirely disengaged from bandages and ties of every description. When the patient is thus placed in bed, every thing favours the natural developement of the beatings of the pulse, which naturally arrive at the organ of touch without any obstacle.

From this rule it appears obvious how contrary to the type of nature is De Haën's advice, that the pulse should be observed while the patient is in a standing posture; for not only many muscles are in contraction when a man is in this posture, and his strength is greatly changed, but there is likewise another inconvenience resulting from it, that the motion of the pulse will be in its turn disturbed, agitated, and, in the end, debilitated, by the incommodious and painful position of the body. The standing posture at length renders languid the vital powers, especially of weak subjects; and when these are not assailed by delirium of the spirit, or other painful sensations, still an occasion is not wanting, that changes the course of the blood and the beatings of the pulse. The advice of the Dutch physician is also re-

jected by Fouquet, when he says : “ On sait
“ les efforts musculaires qui sont nécessaires
“ pour rester debout ou se tenir sur ses pieds ;
“ on sait en même-temps combien ces efforts
“ influent sur le mouvement des liqueurs dans
“ le corps humain, surtout si la personne se
“ trouve un peu faible.”* The positions which
should be preferred to that recommended by
De Haën, are two ; the one is, to observe the
pulse while the patients are in bed ; and the
other, while they are seated.

Before we proceed to the act of exploration
of the pulse, it is necessary to extend the arm,
and place it in a secure position, in order that
it may not vacillate, and at the same time that
the course of the exploration may not be inter-
rupted by the weakness which would necessarily
result from its uncertain and incommodious
situation. The disadvantageous situation of
the arm frequently not permitting, in practice,
the prolongation of the course of exploration
of the pulse ; and suspending its duration,
while it is necessary to prolong it, is directly
contrary to the fifth rule, which is requisite for
observing it well.

As soon as the physician shall have secured

* See Fouquet, *Op. cit.* p. 56.

his arm in a commodious position, extending and supporting it as may be most convenient, he will proceed to the act of exploration, which is the object of the sixth rule. This act consists in applying to the external region of the radial artery the index, middle, annular, and little fingers, which should be so disposed as to be contiguous and straight among themselves, and that their extremities may fall perpendicularly upon the artery. This done, he will compress all the arterial tract comprised within the reach of his fingers, and he will compress the artery more or less, according to certain physical circumstances, which will presently be described. The four fingers being placed in the manner recommended, will present a greater surface to the artery which is the immediate object of observation, and give greater powers, or a more intense degree of capacity to the organ of touch resulting from them : hence it is difficult for the beatings of the pulsatile artery, which remains compressed by the fingers, to escape the organ of touch, however close, deep, and quick they may be. In other words, a larger space of the artery being covered by the four fingers, it becomes less difficult to know and distinguish the characters of the

organic pulses which occur, sometimes in one, sometimes in another part of the pulsatile artery. This is the reason why the pulse should not be observed with one, two, or three fingers only.

In order to observe the pulse, it is not sufficient, as was remarked when speaking of its mechanism, merely to apply the fingers upon the external region of the radial, temporal, or carotid arteries; it is necessary to press the fingers down after having applied them, the pressure being regulated by certain physical circumstances. In general, the degree of pressure must be greater, when the artery is covered with integuments deeply embedded in cellular tissue, as is found in the wrist of fat people, because the integuments of the wrist, thus situated, are an obstacle to the sensibility of the exploratory organ, which they do not allow distinctly to discover the beatings of the artery which they cover. This is the reason why Haller observes: "*Potest etiam valde profundo loco posita arteria micationes efficere obscuriores.*"* The space intervening between the artery and the animal fat is too great to allow us to expect to be able to distinguish

* See Haller, *Op. cit.* lib. vi. p. 246.

correctly the beatings of the pulse, without using a little more pressure than usual.

On the contrary, the artery must be less compressed in individuals of delicate constitution, thin persons, and those of an advanced age, who are all more or less meagre: the radial artery, in all the above-mentioned persons, being little, or scarcely covered with cellular tissue, it is therefore not necessary to use so much pressure in this, as in the former case.

Our opinion upon the arterial oscillations appears to be opposed by that of one of the first anatomists of Europe; we mean John Hunter: while he agrees with us, on the one hand, that the beatings will be more sensible, when the arteries are more superficial; he maintains, on the other hand, that the more an artery is covered with integuments or solid bodies, the greater will be its pulsation. “The dilatation,” in fact, says Hunter, speaking of the arteries, and of the velocity of the blood, in his valuable work on the blood: “The dilatation of the artery producing the stroke, is either felt by the finger, or may be seen when superficial; but were we to judge of the real increase of the artery by this, we should deceive ourselves; for when covered by the inte-

guments, the apparent effect is much greater than it really is in the artery itself; for, in laying such an artery bare, the nearer we come to it, the less visible is its pulsation; and when laid bare, its motion is hardly to be either felt or seen. The more an artery is covered, especially with solid bodies, the more is the pulsation to be felt or seen.”*

The fact is, that the more external the arteries are, and the less embedded they are in the integuments of animal fat, the more sensible, in proportion, is their beating; and of this we have an evident proof in the very sensible beatings of the arteries of old and thin persons, in whom the arteries are more external, because less covered with the cellular tissue, which is in direct opposition to Hunter's opinion. Our reason for insisting upon the observation of the rule of lightly pressing the arteries of subjects of an advanced age, and thin persons, and of giving a firmer pressure in the case of fat persons, is because, generally speaking, the arteries are more or less deep in proportion to the cellular tissue, which prevents the organ of touch from distinctly feeling their beating: we insist the more upon this

* See Hunter, *Op. cit.* p. 307 and 308.

rule, because the value of the observation of the pulse wholly depends upon the degree of pressure. “On trouve quelquefois,” says Fouquet, “des pouls si forts, si élevés, que les doigts en sont comme repoussés ou soulevés; il en est au contraire d’autres, d’une profondeur et d’une petitesse, à avoir besoin qu’on plonge les doigts, en pressant considérablement, pour les sentir.”* “*In pulsu superiore,*” says Dr. Sachero, “*arteriæ motus co superficiales sunt, ut levi digitorum appositione facile distinguantur, et minima egeant pressione. In inferioribus contra profundius sita videtur arteria, ut digitorum apicibus valide sit pre-menda.*”†

The seventh rule is that of observing both the pulses alternately, with the precaution of observing the right radial artery with the left hand and *vice versa*. By not observing both arteries alternately the inconvenience may arise of observing the right pulse, which is regular, for instance, and of omitting the left, which is irregular. Numerous examples of this occur in the treatment of organic diseases; for, in proportion as the organs of the right or

* Fouquet, Op. cit. p. 53 and 54.

† Sachero, Op. cit. p. 61 and 62.

left side of the body are locally affected, the pulse of each side is found to be so likewise: thus it is not rare to find a total want of the right pulse, whilst the left exists, or *vice versa*. Dr. Parry relates some cases of this kind in his work already quoted: among others, he mentions that of a young man coming out of a warm bath, who had entirely lost the pulse in one arm, which did not return till after some months, and even then was scarcely sensible to the touch: the same phenomenon was observed in a middle-aged lady, who was the mother of several children. She was attacked by a severe cough, and when the patient appeared to be convalescent, at the close of the illness, she had also lost the pulse of one arm: she died suddenly a few days afterwards.

Haller also mentions, in his physiology, that examples are found in practice, in which either wrist, nay both, have sometimes been without pulse: and when this phenomenon is not caused by the state of disease, it may arise from the smallness of the diameter of both radials, and from the deep seatedness of either or both of the radial arteries.* It is not sufficient, says Frederic Hoffmann, to feel

* Haller, Op. cit., Lib. vi. p. 246.

the pulse in one wrist only, it must be felt in both; because he remarks it as a fact, that oftentimes the pulse of one wrist differs from that of the other; besides which, there is more facility in feeling one than the other. The necessity of constantly observing alternately the two radial arteries of old persons is the more urgent, as either of them is occasionally found to be partly or wholly ossified: and should the observation happen to be made upon the ossified artery, it might be supposed, without the precaution of alternately examining both, that the disease is serious, whilst it might not be so. Besides, all anatomists agree that ossification is common in both radials of persons advanced in years. “*Toutes les parties du système artériel,*” says Bichat, “*sont sujettes à l’ossification. Elle paroît aussi fréquente dans les branches que dans les troncs. On sait combien il est commun de trouver la radiale ossifiée en tâtant le pouls chez les vieillards.*”^{*} Thus, by not observing both pulses alternately, as the art requires, the risk is incurred of falling into serious errors. Besides, the practice is not a little advantageous, of remarking the dif-

* Bichat, An. gén. Tom. ii. p. 294.

ference, which usually arises from a comparison of both pulses, a difference which contributes to determine with greater certainty the true state of the circulation of the blood, and therefore of all the other functions of life: and when this is not sufficient to show it distinctly, recourse may then be had to the useful but ancient practice of observing not only the radial, but also the temporal and carotid arteries, and even the systole and diastole of the heart.

As to the second part of the above-mentioned rule, of observing the right pulse with the left hand and *vice versa*, the reason of it is the necessity which exists in practice of conveniently extending and supporting the arm in the act of observing the pulse, a circumstance which cannot be obtained, acting in any other manner, as should be done, for the index finger must press upon the base of the styloid apophysis, or rather upon its side which faces the arm.

The object of the eighth and last rule may be reduced to the determining, in a less equivocal or more satisfactory manner, the duration of the observation of the pulse, or the time which should be employed in it. Without imitating in this matter the example of the Chinese doctors, who go to sleep, we

might almost say, with the fingers upon the artery, to such a length do they spin out the examination ; it is our opinion that the period of time employed in the observation of the pulse, should be proportioned to the character of the different diseases. *Cæteris paribus*, therefore, we think that the course of the observation of the pulse should be longer in the organic, and less so in the general simple diseases. In the first place, all physicians well acquainted with sphygmical science know, that the character of the pulse is but slightly pronounced in certain organic affections ; that considerable time is necessary for studying it with the most concentrated attention, before determining its species : always remembering, that in order not to destroy the sensibility of the fingers, the pressure should be occasionally suspended. In the second place, it must be remarked that the organic character of the pulse may very often find itself combined with intermittency, or with some other irregularity ; and this, instead of discovering itself sometimes in the first pulsations, manifests itself, on the contrary, after a course of several beatings ; and by not prolonging, in these cases, the observation of the pulse, the inconvenience may easily arise of observing the pulse, without noticing its irregu-

larities, which more or less decide the character, species, seriousness, or slightness of the disorder. And the inconvenience of prolonging the observation of the pulse, for a greater or less space of time, without sometimes remarking the irregularities which are found in it, is amply compensated by the pleasure of discovering and remarking them, many other times, after numerous regular oscillations which may precede them.

On the contrary, not the smallest advantage results from not prolonging the time of the observation of the pulse in simple hypersthenic diseases, where the excessive excitement is such, that it predominates in them and constitutes their external character: in these the course of the observation of the pulse may be determined by the time which the artery takes in performing one hundred and twenty beats in children; eighty in young persons; seventy-five in adults, and seventy in old persons afflicted with simple hypersthenical diseases: because, as these do not come accompanied by local affections, the whole care of the physician is confined to deducing from the vehemence and celerity of the pulse, or from its fulness and frequency, the degree, as nearly as possible, of the ex-

cessive excitement in which the simple hypersthenic diseases apparently consist. For this purpose we think that the time of the exploration of the pulse is sufficient when the artery performs seventy-five beats in adults; one hundred and twenty in children; eighty in young people; and seventy in old persons; the more so as the monotony of the rhythm of the pulse does not render it necessary for the physician to fatigue the patient with a longer examination.

The rule, however, undergoes a change in the case of compound, or complicated hypersthenical diseases, in which it is always found that the local affections which render them complicated, exercise a species of reaction upon the arterial system, and consequently upon the pulse: likewise, when it is required to estimate the degree of violence or of excessive excitement, constituting the general character of hypersthenical diseases, and to observe simultaneously the organic characters of the pulse, which indicate the presence of the local affections; to become familiar with all these general and local alterations of the pulse, the above-mentioned time cannot be considered as sufficient. The time employed by the artery in performing one hundred and

twenty beats, would be, neither long enough to fatigue the physician, nor so short as to suspend the observation of the pulse, whilst it might be advantageous to continue it. The same time, likewise, affords an opportunity of discovering, knowing, and studying the progress of organic pulses in local affections, and likewise in chronic diseases of long standing, which are scarcely ever unaccompanied by local affections, or by organic diseases, which support them, and are the most frequent cause of their obstinacy.

But if it be not so requisite to prolong the time of the observation of the pulse in simple hypersthenical diseases, as in organic and chronic ones of long standing, it is, however, necessary to repeat it, in the first case, two or three times in the course of the day; that is, in their access or paroxysm, in the remission, and not unfrequently, also, in their successive developement; whilst this necessity of repeating it in chronic diseases, which most frequently proceed uniformly, and preserve the same character, obviously does not exist. The object of the threefold observation of the pulse, in acute disorders, simple, compound, or complicated, is to appreciate the intensity and strength of their attack in the paroxysm, as well as their more or less rapid progress in

their developement, and the state in which the vital powers are found in their remission or decline; information the more important, as it must guide the mind in the selection of the preliminary conditions of the plan of cure. On the contrary, this not being the case with chronic diseases, which advance slowly, and proceed free from the rapid changes to which acute disorders are naturally subject, there is, therefore, no necessity in these, as in the others, to examine the pulse at least twice in the course of the day.

Having now succeeded in ascertaining the reason why the heart and arteries have the power of oscillating at the stroke of the blood, in what manner their beating is performed, and how the pulse should be examined, in order to derive the greatest advantage from it; after all these preliminaries, it will now be expedient to examine the natural pulse of man under every aspect; or what is the same thing, his physiological state, a state which will serve as a guide in the study and knowledge of the different morbid pulses, as those that conduct the physician in the intricate and difficult road, which leads to the diagnosis, prognosis, and indication of the different diseases to which the human race is exposed:

ART. VII.

PHYSIOLOGICAL STATE OF THE PULSE.

OF THE CHARACTER OF THE NATURAL PULSE OF MAN,
CONSIDERED WITH RESPECT TO THE DIFFERENT
PERIODS OF LIFE.

CONFORMABLY to the philosophical principle of proceeding from positives to negatives, in order that by means of the former we may acquire a knowledge of the latter, we propose examining, under every point of view, the natural pulse of man, that being the object of positive ideas; thence we shall proceed to investigate diseased pulses, which, on account of their being inseparable from the state of disease, represent the negative ideas which it is our wish to acquire. In fact, to enter immediately upon the examination of morbid pulses, before having become acquainted with the various forms of the natural pulse, would not only be an erroneous plan, but it will also be advantageous to compare the latter with the former, to discover the difference between them. And how is it possible to note upon two grounds the presence of any morbid pulse, when the mind has not a clear conception of

the natural one? “*Cum in omni rerum naturalium historia,*” says the profound Haller, “*utile sit mensuras definire et numeros, hic in signo adeo gravi, adeo perpetui usus, et primario omnis prognoseos fundamento, utilissimum fuerit accuratius, perque numeros, determinasse, quis sit sano homini pulsus, quis febrienti, ut distantia a valetudine integra, adque eam reditus ad certiore rationem definiatur.*”*

Without the previous knowledge of the pulse, naturally great, small, hard, soft, strong, weak, quick, slow, &c., it is in fact impossible to distinguish when these pulses are morbid. The strength, weakness, greatness, smallness, celerity, slowness, frequency, and rareness of the pulse indicate, as far as a certain point, the state of health in one individual, and that of disease in another. Thus comparing, for instance, the pulse of a florid, robust young man with that of an individual of a delicate complexion, it will be remarked, that the pulse of the one is strong, while that of the other is weak: now, if the strength of the pulse of the former is observed in that of the latter, it will be morbid in this, and natural in the other; and, on the contrary, if the weakness of

* Haller, Op. et loc. cit. p. 258.

the pulse of the individual of delicate complexion be observable in the pulse of the robust young man, it will likewise be morbid in the latter, whilst it is natural in the former. The same observation holds good in thousands of other instances, because it is an established principle in practice, that the same pulse may be the index of the healthy state in one individual, and of the morbid state in another.

It was therefore indispensable to point out, one by one, all the natural pulses, or which is the same, all the variations and modifications, with which the natural pulse of man discovers itself in the different periods of life, in the various statures, and in the different sizes of the body, in either sex, in the various temperaments, and in the different countries, &c. From these sources of information results the advantage which is obtained, of being able to distinguish, upon all occasions, the natural pulse from the morbid one properly so called. On the contrary, without this point of comparison, every attempt at judging whether this or that pulse were morbid or healthy would certainly be futile: it would be equivalent to the desire of ascertaining in what darkness and cold consist, without first knowing the nature of light and caloric. “ Nous ajouterons à titre de

“remarques générales,” says Fouquet with much truth, “qu’avant d’en venir à l’observation du pouls sur les malades dans les hôpitaux, et à aucune recherche particulière sur les pouls organiques, il convient d’abord et préliminairement de s’exercer pendant quelques mois sur le pouls des personnes bien portantes, et de se rendre familière la connoissance de ces modifications.”*

Now, in order to observe (as is requisite) the variations of which the natural pulse is capable in the different periods of life, we purpose to examine it step by step in the gradual developement in children and young persons, and in the successive changes which take place in the organization of adults and old persons, although the developement of those, and the changes of the organization of the others, are not obvious to the senses, and are imperceptible to the mind, according to the law of gradation by which similar phenomena in the human machine are affected. The method, followed by many writers, of examining in a general manner the variations of the pulse in the different periods of life, is too loose, vague, and imperfect; this opinion is

* Fouquet, *Op. cit.* p. 58.

founded upon the difficulty of precisely defining the limits of the various periods of life. Nature, it is true, has fixed a certain time for the developement of animals; but that time, on the other hand, is sometimes accelerated, or delayed by the influence of different climates, modes of living, education, &c.; so that it is not feasible, in practice, to establish the limits of the different periods of life.

Who is ignorant of the fact, that the periods of the life of an inhabitant of Asia are most rapid, whilst, on the contrary, those of the life of an inhabitant of the north are extremely slow? And, whilst it is the most general opinion that the male acquires, in Europe, the developement of his body at the age of eighteen, and the female at fourteen, there are, at the same time, numerous instances in the empire of the Great Mogul, of men becoming fathers at the age of ten, and females acquiring the title of mother at eight.* Who now would pretend to fix the precise time of youth, puberty, manhood, and old age? A Russian cannot be perfectly developed till he attain the age of twenty-five years, whilst an Asiatic is at the same age considerably ad-

* Sinibaldi, *Traité d'éducation physique*, p. 125.

vanced, if not old. “ On remarque quelque-
 “ fois” says Pinel,” “ une certaine précocité
 “ de l’éruption des menstrues, même en Eu-
 “ rope, à la neuvième, dixième ou onzième
 “ année. Dans les régions de l’Asie, il n’est
 “ pas rare de voir de jeunes personnes de huit
 “ ans s’engager dans le mariage, et devenir
 “ mères à la neuvième année.”*

These observations justify us in the opinion, that the division of human life into so few determinate periods is imperfect, if not arbitrary: thus far is true, that the authors who have treated upon this subject do not agree, either as to the number or the length of the various periods, into which they believe the course of human life to be divided; for, some of them make the course of life to consist of six periods; viz., infancy, or childhood; puberty, or adolescence; youth properly so called; the adult or virile age; old age; and, lastly, decrepitude: others, and these are the more numerous, reduce it to four periods; infancy, puberty, adult age, and old age.

Authors likewise differ as to the length of each period. There are some who think that the period of life represented by infancy ex-

* Pinel, Op. cit. Tom. ii. p. 634.

tends to the seventh year, while others limit it to the fifth: a third class carry the period of puberty as far as twenty-five; others again fix it at twenty-one, and others, at eighteen years; and thus of all the other periods whose length is arbitrarily fixed by the mind, and not determined by nature. The reason of this discrepancy of opinion is to be found in the pride of man, who wishes to domineer over nature by vainly attempting to subject her to the laws of his own imagination. The fact is, that the human race is composed of individuals, not of classes; hence the fallacy of the principle of applying the same laws to all, since we see that it is utterly impossible to find in nature two individuals resembling each other in every point.

But, without engaging in similar inquiries, which might lead us from our object, and without being under the necessity of exactly ascertaining the number and length of the various periods of life, which have been fixed by different writers; we, who are at present sufficiently prepared for appreciating them as much as we require, shall, with a knowledge of the cause, proceed to the examination of the variations which the natural pulse of man exhibits through the whole course of his life: with this proviso, that if, for the purpose of

getting rid, on the one hand, of the inconveniences arising from the defect of any method whatsoever, and if for the purpose of avoiding, on the other, the necessity of treating at length upon similar subjects, in order to introduce our own views, upon the abstract and arbitrary division of the various periods of life: if, we repeat, to avoid both these inconveniences, we consent to follow them *pro tempore*; we shall not the less avail ourselves of the necessary means of avoiding their defects.

Entering, therefore, upon our subject, as we have proposed, we shall observe for the present, that the natural pulse of man sensibly varies in proportion to the more or less rapid development of children and young persons, or according as the changes which inevitably take place in the organization of adults and old persons are more or less marked: proceeding upon this datum, it becomes of little or no importance to dwell longer upon the number and the length of the various periods of life, it being our intention to direct our mind to the organic and physical causes, which primarily make the natural pulse of man to vary, and not to consider the above-mentioned periods independently of this important particularity.

That man's natural pulse varies in propor-

tion to the changes which take place in his organization, is an indubitable truth, the evidence of which is supported by the testimony of nature herself, when we observe that the pulse of man, without losing an atom of its natural character, can indicate the state of health in three individuals of different ages, although it may be quick, frequent, and small in the first; elevated, full, and strong in the second; and slow, rare, and hard in the third. The pulse is, in fact, quick, frequent, and small in children; elevated, full, and strong in adults; and slow, rare, and hard in old persons. But it is not sufficient to know, or to say, that the pulse is quick, frequent, and small in children; elevated, full, and strong in adult age; and slow, rare, and hard in old persons: to this information it is requisite to add the knowledge of the fact, that the celerity, frequency, and smallness of the pulse in the period of infancy vary in degree and strength; that the same takes place with respect to its elevation, fullness, and strength in adult, and its slowness, rarity, and hardness in old age.

In fact, commencing our observations by the first period, namely, that of infancy, we would have it observed that organization never remains stationary during the course of life,

and much less in the period of infancy: for, it is in this period that a daily change takes place in man's organization; and if this change takes place, although imperceptibly, in the short space of twenty-four hours, how must this same organization vary from one month to another, and in the revolution of one, two, or three years? This is one, among the many other inconveniences, which clearly demonstrate the imperfection of the division of human life into so few periods; infant is the name given to a being of a year old, a name which he still retains when he has attained his fifth or sixth year. Now how much more conformable to the laws of the animal economy would be the practice of taking our model from the type of nature, which is shown by the condition of the developement of an infant's body, rather than abstractedly from the period of its infancy, as well in the administration of food in a healthy state, as in the prescription of different remedies when in a diseased state.

In proportioning, as is the custom, the dose of any medicine to the period of infancy, and not to the temporary physical and organic circumstances of the infant, is another abuse unworthy of the present age. It is the progress which the body of an infant makes

towards its developement, and not the secondary circumstances of the age of infancy, which is the cause of the variations of the pulse; since, without quitting the limits of infancy, and without any other cause, except that of its developement, the pulse of an infant gradually acquires, in its successive course, a little more strength and energy; and what it acquires in this respect, it loses proportionably in quickness and smallness. The heart of the foetus just brought into the world is in the highest degree excitable by the impulse of the blood; its contractions and dilatations succeed each other, for reasons already seen, with the utmost rapidity, and the blood, which is consequently expelled from it with the same rapidity, necessarily compels the small and tender arteries to repeat in the same manner their systole and diastole; and hence the beatings of the pulse of the tender infant are quick, frequent, and small.

Hence, in proportion as the body of a child proceeds, although insensibly, developing itself in the successive course of its first period; in this time of increase and developement, its heart becomes proportionably less excitable; the structure of this organ makes fresh progress, and acquires, at the same time, a few

degrees of consistence and solidity: for this reason, therefore, its contractions and dilations should not succeed each other with such frequency, because its excitability is somewhat accustomed to the action of the blood: from these physical circumstances the change of the pulse arises, which, from being very quick, as it is in the first moments of life, gradually becomes less rapid, and more developed, its rhythm commencing to become more pronounced and more distinct; the more so as the arteries, which are the material instrument of it, become somewhat increased in diameter, and the state of the vital powers of the infant is improved in the successive progress of its developement.

The improvement of the physical state of the infant, which continues to be gradually developed, is deduced from the observation of the pulse, which, instead of performing a hundred and forty beats in the short space of one minute, as it does, either more or less, in the first moments of life; at the end of a year, does not perform more than about one hundred and twenty; one hundred and ten about the second year; ninety-six or a hundred in the third; and so on in proportion for succeeding years; that is, the celerity of an infant's pulse sensibly

decreases, in proportion to the advance of its body towards developement: this is so true, that near the close of the seventh year, the last stage of infancy, the pulse rarely performs more than eighty-five beats in the course of the first minute.

Now if it be true, as is proved by observation, that in the first moments of life the pulse of an infant performs one hundred and forty beats in the course of the first minute, and at the same time only eighty-five in the last stage of infancy; it will be equally true that the difference of fifty-five beats, a difference which evidently results from the comparison of the celerity of the pulse between the first and last stages of infancy; that this difference, I say, is sufficient to demonstrate to conviction, that the organic dispositions of an infant successively vary, in proportion as its physical increase advances along the entire period of infancy. Hence the word infancy is wholly abstract in medicine, when allowance is made for the degree of developement which an infant has been able to attain in more or less time: and this allowance is made in order to acquire the general idea of infancy: in short, it is the rapid or slow increase of the body of an infant, and not the year of infancy which it

may reckon, that decides the merit of his vital powers, and which should guide the physician in the treatment of the diseases of children.

Man, then, passing from the first to the second period, which is that of puberty, the increase of his body makes fresh progress, and the tone of the pulse is considerably improved. Man's organization, which likewise does not remain stationary in the period of puberty, as it continues improving and consolidating itself more and more; must, as it actually does, have a direct influence upon the variations of the pulse, which, whilst it does not beat with such frequency, is also distinguished from the pulse of infancy, by its beats being much more pronounced, and more developed than those of the pulse of an infant. But it does not suffice to say, that the pulse is more developed and less quick in puberty; and that therefore it does not perform more than eighty beats in the short space of the first minute: the object is rather to follow, by the progress of the science, all the variations from the first stage of puberty to the commencement of the virile age, in which the pulse of man acquires the *maximum* of its strength and energy; otherwise, the error might be fallen into, of concentrating into one

point all the successive advances made by the pulse, from the termination of infancy to the commencement of the virile or adult age, which includes the period of eleven, or, according to others, of fourteen years; and it certainly is not possible that the physical increase which the body of the man gradually assumes in all that time, should not influence the advance which is necessarily made by the pulse, which gradually acquires, by this means, more body in the stage of puberty; a period in which concur, for this purpose, the developement of the nerves and artères, and even plethora, which there predominates.

Whilst the organs of man are developing themselves, they increase in volume, and always gradually acquire, in puberty, consistency, strength, and solidity, exactly corresponding with the general increase of the body; and the functions which follow the fate of the organs succeed likewise by degrees, in exercising themselves with a certain luxury, a luxury to which we must attribute that powerful tone taken by the circulation of the blood, and consequently the beating of the pulse, which there operate with like energy and force. “*Le système vasculaire,*” says Dumas, “*dominé par les systèmes nerveux, lymphatique*

“ et viscéral, pendant l'enfance, acquiert un
 “ surcroît d'énergie, et se saisit à son tour de
 “ la prédominance, lorsque le travail de la
 “ puberté amène la révolution orageuse de
 “ l'adolescence.”* The phenomenon of puberty is announced in man, as every one knows, by the deep tone of the voice, by his free carriage, and his animated and intelligent looks; and in woman, by the developement of the bosom, by timidity and chastity, by the nervous character, and by the appearance of the menstrual discharge.

In such a state of physical increase of the organs of the circulation of the blood, the energy and strength of the contractions of the heart increase in like manner, whence proceeds the developement of the pulse, which manifests itself externally, in proportion to the physical improvement of the causes which produce its action: and whilst, on one hand, the pulse gains on the side of energy and strength, it loses, in puberty, on the contrary, the privilege which it had of beating rapidly in the period of infancy, and supplies its place with the strength and energy which it has acquired; a circumstance which evidently proves

* Dumas, Op. cit. Tom. ii. p. 437.

that the celerity of the pulse is in inverse ratio with its strength. The other circumstance to be observed respecting the pulse which characterizes the period of puberty, is that of not concentrating the improvement of the pulse in any one point of puberty, whilst it is gradually improving itself along the whole period of it ; unless we are thus careful, we shall act against the laws of the gradual developement of the organs, from which arises the successive improvement of the pulse in puberty. The state of the pulse, therefore, of young persons, when diseased, should not be valued and estimated by the equivocal rule of their age, but should be calculated according to the condition of their physical increase and developement, which may be at one time rapid, at another slow, and which may not exactly correspond to the type of their age.

Similar deductions result from the observations relative to the successive changes which the natural pulse of man undergoes through the period of adult or virile age. The pulse of a healthy adult is generally strong, equal, rather flexible, free, and moderately quick ; but the pulse does not preserve this character through the successive course of virility, since it is gradually altered by the

physical causes which successively modify it. The capacity and strength acquired by the ventricles of the heart and arteries, in the adult age, allow both of these to receive a greater column of blood, and consequently to perform stronger and more marked contractions and dilatations in the period of virility; whence results the calibre of the pulse of the adult. Both these causes, the capacity and strength of the ventricles of the heart, and arteries, which have arrived at the maximum of their natural growth, acting in concert, produce the strong, full, free, rather flexible, and moderately quick pulse, which is proper to the well-organized and healthy adult.

But, as the strength of the ventricles of the heart and arteries is not kept up through the more advanced stage of virility, it naturally follows that the value and state of the pulse of the adult must be deteriorated in proportion to the deterioration of the causes which set it in motion; and this is precisely the case with man, in proportion as he removes more and more from the period of puberty, in his approach, though gradual, to old age. To say, as is usual, that the pulse of an adult performs seventy-five beats in the course of a minute, and that its beats are stronger and

more vigorous than those of the pulse of a young person, and much more so than those of an infant's pulse, is, it is true, equivalent to pointing out the difference which distinguishes the natural pulse of the adult from that of a young person, and of an infant, of which it fixes the line of demarcation : but still, this same difference does not determine all the variations which the pulse of the adult exhibits in the successive stages of his entire period ; and it would be an extraordinary effort of inconsistency, to endeavour to maintain that the pulse of an adult of fifty years of age, has, under similar circumstances, the strength, fulness, flexibility, and quickness, of the pulse of another individual of thirty years old ; nor can it be said that both individuals are not in the same period of adult age : for this extends, as every one knows, from the age of twenty-one, according to some, or twenty-five, according to others, to that of fifty years. At any rate, it may be said, that a person has nearly reached the maximum of the period of virile age at fifty, whilst he who is in his thirtieth year is but entering on it : yet neither of them is, on that account, the less within the limits of adult age.

The deterioration of the pulse of an adult,

in the more advanced stage of his period, is a necessary consequence of the previous deterioration of the tissue of the organs: when the organization of the adult arrives at its highest degree of improvement, it must necessarily retrograde; for it is no longer allowed either to advance, or to remain stationary: this explains the reason why the organization of man gradually wears out in the course of the adult age; since the pulse of an adult cannot preserve itself in the state of strength, energy, flexibility, and moderate quickness, a state which is only compatible with the first, and not with the after-stages of its period: with this difference, that while the celerity of the pulse is in inverse ratio to its strength and fulness in the period of infancy, and in that of puberty, it decreases, on the contrary, with the diminution of the strength and fulness of the pulse in the more advanced stages of the period of adult age, and along the whole course of old age and decrepitude, in which every thing is on the progressive decline with the vital powers, and the contractions of the heart and arteries. Upon this progressive decline of the vital powers is founded the reason of estimating the variations of the pulse of adults by the various degrees of their period,

dégrées which indicate the true state of their organs, and which it is impossible to concentrate in a single point.

The deterioration of man's structure or tissue becomes still more sensible in the period of old age, where every thing points out, at one and the same time, the effects of the accumulation of years, the long exercise of life, the waste and induration of the fibres of the heart and arteries, and the prostration of the vital powers, the immediate cause of the slowness, rarity, and hardness of the pulse, all which united, characterize the period of old age: thus, the whole body of a man advanced in years generally appears withered and dry, because it has usually but a scanty supply of blood, and of white, or secondary humours.

“ J’ai disséqué,” says Bichat, “ plusieurs animaux vivans, dans le dernier âge; or c’est un phénomène remarquable, que le peu de sang que les petits vaisseaux contiennent, en comparaison de ce qu’on observe sur les jeunes animaux.”* The voice of experiment, however, had no effect upon the followers of Botal, who even in the most trifling disorders did not spare the blood of people advanced in years.

* Bichat, Op. cit. Tom. ii. p. 368.

The blood, being diminished in quantity, cannot stimulate, with its wonted efficacy, the ventricles of the heart, and the arteries of old persons; and the feebleness of the contractions of both of them produces, in its turn, the slowness of the circulation of the blood, and the beatings of the pulse. “Remarquez,” says Bichat, “que toutes les fonctions de l’enfant, soit organiques, soit animales, sont caractérisées par une vivacité, par une impétuosité qui contrastent avec la lenteur et le peu d’énergie de celles des vieillards.”*

In general, the capacity of the arterial system of old people becomes circumscribed; because the largest arteries then contract themselves, and their diameter becomes less, and the smaller ones are for the most part obliterated, or transformed into so many small ligaments: hence, the smallness of the quantity of the blood in old people necessarily required that nature should circumscribe the round of its circulation; the more so, as the heart, which has already lost, as before observed, in old age, a part of its former energy, cannot propel the blood with sufficient force to allow it to perform a more extended circulation, neither

* Bichat, Op. cit. Tom. ii. p. 368.

can this extended sphere of arterial vessels be sensible of the beneficial effects of the general vibrations which the heart communicates to the whole arterial tree, on account of the feebleness of its contractions ; whence proceeds the rarity of the pulsatory beats in old persons.

With age, also, the thickness and density of the arterial tunics increase, because their fibres gain in elasticity what they lose in flexibility and softness : and, whilst the arteries acquire, in old age, a greater degree of hardness, rigidity, or asperity, they no longer retain the energy and strength which are found in the period of youth, and which become enervated by the waste of life. The density or tension of the arterial tunics is therefore the cause of the hardness of the pulse, which occurs in the period of old age. As to the slowness of the pulse, another characteristic of this period, it arises, as before observed, from the weakness of the contractions of the heart and arteries, and also from the wearing out of the general strength, to which we must attribute the reason why the pulses of aged persons do not in general perform more than seventy beats in the space of a minute.

But it must be also observed, that it is not immediately on entering upon old age, when

man passes into it from the period of manhood, that the pulse becomes slow, hard, and rare; on the contrary, the hard, rare, or slow pulse never fails to follow the gradual deteriorations which progressively succeed each other in the organization of old persons; nor is it because any individual is in the period of old age, that his pulse should constantly beat seventy times in the space of a minute, and be equally hard throughout the whole course of old age which borders upon decrepitude. Observation, at least, demonstrates the contrary; for we see that the hardness, slowness, and rarity of the pulse progressively advance throughout the entire period of old age, a circumstance which does not allow us to estimate the variations of the pulse of old persons in a state of disease by the equivocal datum of their age, whilst the real one is to be found in the precise degree of deterioration of their physical system, and in the state, whatever it may be, of their vital powers; because, instances are not rare in practice, of the pulse appearing decidedly hard, slow, and rare, in some old persons, and but slightly so in others, although of the same age.

Finally, in proportion as man unhappily advances towards the last stages of decrepi-

tude, the natural termination of life, the decay of the vital powers increases by the same laws of gradation; the fibres of the heart and arteries grow hard, and are successively worn out; their contractions act feebly upon the blood, which, as it only penetrates slowly and with difficulty through the capillary vessels of the extremities of the body, and the pulse, which always partakes the fate of the vital powers of the heart and arteries, and consequently of the circulation of the blood, cannot but be slower, harder, and more rare, in decrepitude, in which state the pulse does not generally perform more than sixty beats in the course of a minute.

Another convincing proof of the successive deterioration of the physical system of man is to be found in the period of decrepitude; for when a man is passing through this period, besides his pulse becoming gradually harder, slower, and more rare, we remark with greater facility the deterioration of the pulse, which, as if it were now tired of beating, ceases distinctly to enunciate the expressions of nature, worn out and oppressed by the insupportable weight of the accumulation of years, and instead of beating, we observe certain incomplete, obscure, frequent, and unequal oscillations, so

that the slowness, hardness, and smallness of the pulse have always gradually followed the waste of the tissue of the organs; these variations at length become confounded with a kind of undulatory motion of the artery, which is the more obscure and weak, in proportion as life languishes in the last degree of decrepitude. All the organic and animal functions seem then to be on the point of detaching themselves from their closest bonds, and even if the slightest accident or disorder does not supervene to effect their disunion, life consumes and exhausts itself for mere want of vitality, exactly in the same manner as a lamp becomes extinguished for want of oil or other combustible matter.

ART. VIII.

OF THE NATURAL PULSE, WHICH VARIES ACCORDING
TO THE DIFFERENCE OF SEX, IN PROPORTION
TO THE STATURE AND BULK OF THE
BODY AND TO THE DIFFERENT
TEMPERAMENTS.

BESIDES the variations of the natural pulse which proceed from the progress that organization successively makes in infancy and puberty; besides those which are the immediate effect of the gradual deteriorations that take place in the organization of adults, old, and decrepit individuals; in addition to these natural variations of the pulse, there are others which result from the different organization of individuals of either sex, from their various stature and bulk, and also from their particular temperament. These are so many intrinsic causes, which from their modifying the exercise of the circulation of the blood, necessarily influence the variations of the pulse.

Amongst other effects and phenomena, arising in fact from the different organization of individuals of either sex, that is particularly to be noticed, which concerns the variety of the

pulse, and sensibly distinguishes them. The pulse of women is, in general, small, quick, yielding, and energetic; whilst that of men, on the contrary, is, as before observed, strong, full, and developed: and, although we compare the natural pulse of females with that of males of an equally adult age, it does not require a profound acquaintance with the art, to distinguish the former from the latter in any other period of life whatsoever, the pulse of females being always, *cæteris paribus*, smaller, quicker, more yielding, and more energetic, than that of individuals belonging to the other sex.

The nerves of females, compared to the bulk of the other parts of the body, are larger, and much more fragile than those of men; nature has given them a physical constitution more delicate, finer, and consequently more sensible; and they therefore enjoy a life of greater excitability and energy; I say of greater energy, because their organs are likewise smaller: hence females generally have not the body so large as that of men, nor is their stature so tall: and as the activity of the vital movements is found, as every one knows, more concentrated in bodies of smaller size, the reason is obvious why the pulse of females is quick, small, yielding, and energetic, and,

on the contrary, that of males strong, full, and developed; and whilst females possess greater sensibility than men, they have also the heart and arteries more excitable, arising from the other favourable circumstance of the state of plethora, which predominates in their organs, and accelerates in them the course of the circulation of the blood.

The difficulty of distinguishing the difference of the pulse in the two sexes, is scarcely ever found in young men, who bear at first sight a striking resemblance to females, as much from their delicate conformation, as from their habits, tastes, and moral character; but the difference of their natural pulse does not become the less apparent, on that account, to the acuteness of the organ of tact, the moment that the model of the organization of the one really differs from that of the other: it will be seen in practice, that whatever analogy there may exist between their organization, the pulse of persons who are thus delicate, never becomes so small, quick, yielding, and energetic, as that of individuals belonging to the female sex.

The natural pulse of man varies likewise in proportion to his stature. In short persons, the pulse is strong, full, quick, and energetic; in tall ones, it is slow, rare, not so full, and

but little, if at all, strong. The heart of short persons is larger, relatively to the bulk of the body, than that of tall ones; the contractions of its ventricles are consequently more powerful, and stronger in proportion, and drive the blood into the arteries with greater force; these latter, which correspond to the size of the heart, hasten on its course, by their energetic contractions, and the blood, which performs a shorter and more circumscribed course in the man of short stature, must necessarily force the veins to discharge it in greater quantity, and in less time, into the auricles, whence it rapidly passes into the corresponding ventricles; and, it is this concurrence of physical circumstances which causes the pulse to be strong, energetic, full, and quick, in short persons. Albert Haller likewise attributes the frequency of the contractions of the heart to the copiousness of the sanguineous wave, and to the large size of that organ, when he says: “*Altera causa, quæ facit, ut cor frequentius contrahatur, abundantia est stimuli, cujus denuo varii fontes sunt. Simplicissimus est, qui a magno corde nascitur; magnum voco, quod pro reliqui corporis portione magnum est.*”*

* See Haller, Op. cit. lib. vi. p. 249.

The strength, fulness, quickness, and energy of the pulse of short people, are to be attributed also to the vivacity of their passions, the activity of their motions, the celerity of their operations, and the concentration of their strength, which made Pliny to say, with much justice: "*Nusquam magis quam in minimis tota est natura.*" So that from the size of the body, we may very well presume what should be the state of the circulation of the blood, the value of the natural pulse, and the tone of the vital powers. This state of activity in subjects of short stature is also the cause of the greater intensity and severity of phlegmasiæ and inflammatory fevers, and all other diseases arising from plethora: these, when not opportunely treated by repeated bleedings, proceed with such rapidity and force, as not to allow nature sufficient time to oppose an effectual resistance: if, however, the rapid progress of phlegmasiæ and inflammatory fevers is to be dreaded in persons of short stature; on the other hand, the effects of *spectatrix* medicine generally prove successful in the treatment of slight and superficial acute complaints, nature being energetic and strong in short persons.

The reverse of the medal, will describe the

physical state of individuals of tall stature: the pulse of such persons is, for the most part, slow, rare, of little fulness, and but little, if at all, strong: the passions are roused with difficulty, or do not possess the requisite vivacity; the vital movements are slow, and the operations both of the mind and body tardy. This state of things arises from the physical circumstance, that in tall persons the heart is not proportionately large and strong; hence, the strength of this organ is not sufficient to communicate to the arterial tree that vibration which ought to be felt by every part of the body: the red blood, which does not receive the impulse, requisite to make it circulate throughout the system with the necessary quickness, cannot pour into it, within a given time, the nutritive particles which renovate its vigour; the arteries, but slightly stimulated by the slow course of the blood, react upon it only in a feeble manner, and hence arise the little strength of the organs, the slowness of the exercise of the circulation of the blood, the small value of the natural pulse, and the languor of all the vital motions. This also is the reason why, in tall persons, phlegmasiæ, inflammatory fevers, and all the other morbid phenomena of a similar nature,

are not the objects of much dread; and the effects of Stahl's "*ars sanandi cum expectatione*" almost always prove fruitless, however slight and feeble the nature of the complaint, in persons of tall stature.

Observation proves to us that the energy of the vital motions is in an inverse ratio to the largeness and bulk of the bodies of animals; for, whilst the pulse of the elephant performs but very few beats in the course of a minute, that of the horse performs proportionately, in the same time, from 32 to 34; that of the ox from 36 to 38; that of the sheep nearly 64; that of the dog almost 78, and that of pigeons more than a hundred. The truth of this observation will be the more evident, upon comparing the pulse of an infant, which beats one hundred and forty times in the short space of a minute, during its first moments of life, with the pulse of an individual perfectly developed, which performs only seventy-five beats in the same time, as is certainly the case with the pulse of an adult.

The temperaments, which are produced by the peculiar dispositions that the organization of different individuals of the human race receives from Nature, have a direct influence upon the variations of the pulse. That every

particular temperament causes, in its own peculiar way, the natural pulse of man to vary, is proved, as will be seen, by observation : in order, however, to avoid giving, as has hitherto been done, an erroneous description of the variations of the pulse, which proceed from the various temperaments, it is incumbent upon us, before explaining them, to determine what we mean by temperaments, and what is our view of their distribution. We think that it is of the greatest importance in researches of this kind ; first, to ascertain the idea which is to be attached to the word temperament, and then to inquire what are the relations which unite the different temperaments with the different pulses, which proceed from them : and since we are upon the investigation of this point of medicine, it will not be amiss to contemplate, for a few moments, the old ideas entertained upon the subject of temperaments.

In the first place, the origin of temperaments may be traced back to a very remote period ; at the same time it may be shown that the first ideas of them were derived from erroneous principles. To say the truth, the present state of physiology offers no inconsiderable means of reforming the doctrine of temperaments, the exact

and correct knowledge of which is intimately connected with the improvement of practical medicine. It appears to us, that the origin of temperaments may be traced back to the discovery made by Empedocles, a Sicilian philosopher, and disciple of Pythagoras, of the then four elementary substances of the human body; viz., air, water, fire, and earth. From this erroneous principle, the pneumatic sect derived the ideas of hot, cold, moist, and dry; whence their followers likewise drew the hot, cold, moist, and dry temperaments.

According to the physicians of antiquity, the temperament does not differ from that disposition of the human body which results from a varied mixture or combination of the four elementary substances before mentioned, invented by Empedocles; that is, air, water, fire, and earth; or, in the language of the peripatetics, hot, cold, moist, and dry; and, from these elements, variously mixed and combined, the ancient physicians derived the different temperaments. Others succeeded them, who believed that the blood was a kind of imperfect mixture, and that it was composed not only of the four above-mentioned simple or primary substances, but also of four other secondary ingredients; these were, and are

still, unfortunately, *anger, phlegm, melancholy, and blood*; and hence, in proportion as they thought that one humour predominated over the others, they denominated the temperament *choleric, phlegmatic, melancholic, or sanguineous*; always, as before observed, in proportion to the superiority of one over the other secondary ingredients. Hippocrates was led into a similar error, he having likewise considered the human body as a substance composed of blood, phlegm, bile, black bile, &c. His follower, Galen, adopted these principles, by admitting, as he did, the said four substances and their modifications: thus, Galen made them the basis of his theory of medicine, called, on that account, humoral; since, in the treatment of different diseases, his sole object was to abate the excessive degree of the humoral qualities.

Almost all the followers and successors of Hippocrates and Galen adopted these erroneous principles, and, by propagating them, they induced those who came after them to set a value upon these ideas respecting the temperaments: so that they have always predominated in past ages, and still maintain their ground, even now, in the majority of medical schools. In fact, the greater number of writers of the present day continue to derive the different

temperaments from the various proportions of animal humours. “The temperament,” says an eminent modern writer, “is the peculiar constitution of the humours. Temperaments have been variously distinguished: the division most generally received is into the sanguineous, phlegmatic, choleric, and melancholic.”* We have here quoted the author’s own words, not with the intention of criticizing in the least degree what he says, but solely for the purpose of supporting our own assertion, that the division into sanguineous, phlegmatic, choleric, and melancholic temperaments, is decidedly the one most generally received.

It will be well to observe, in this place, that the above-mentioned temperaments of the moderns do not differ in the least degree from those of the physicians of the remotest antiquity, the basis of their division resting upon the same principles. The sanguineous temperament (to produce here an instance of the uniformity of their principles), in which the blood predominates over the bile, phlegm, and melancholic humours, corresponds, at the same time, to the warm and moist temperament of the ancients, and consequently to

* See R. Hooper, Medical Dictionary, *p.* 879.

the air of Empedocles: the phlegmatic temperament is made to point out the superiority of the phlegm over the other humours, and also corresponds to the cold and moist temperament of the ancients, and consequently to the water of Empedocles; the same is to be observed of the bilious or choleric temperament, which corresponds to the warm and dry of the ancients, and therefore is analogous with the fire of Empedocles, and the last, which is the melancholic, likewise corresponds with the cold and dry of the ancients, and consequently with the earth of the Sicilian philosopher, who was the first inventor of them. Thus, it is clear, from what has hitherto been said, that the origin of temperaments is to be found in the invention, which Empedocles is said to have made, of air, water, fire, and earth; an invention which was followed by the peripatetics, who made the temperaments to consist in the imaginary mixtures or combinations of hot, cold, moist, and dry, which we justly consider as so many accidental qualities, foreign to the organization whose peculiar and varied modifications may more justly be considered as constituting temperaments properly so called.

The fact is, that all the humours are neces-

sary to the preservation of human life; but they do not constitute vitality, nor even organization. The blood, the bile, and all the other secondary humours, have nothing to do with the organization, tissue, or structure of the various organs: the humours exist in the human body, and are the springs from which the various organs derive the elements of their strength and preservation; but it does not follow that the humours have life, and feel like the nervous, muscular, arterial, and venous fibres, &c.; and since the different animal humours do not assume the aspect, solidity, and character of fibres, by reason of the assimilating functions, all efforts to prove that the humours are sensible parts of the human body must be fruitless. And if the blood and white humours are not alive, do not feel, nor constitute any part of the tissue, organization, or physical constitution, which results from it, how can it be presumed, without error, that the peculiar dispositions of animal humours can give rise to the different temperaments?

If the temperaments were, as it is pretended, the mere produce of the various combinations of the humours, they could not point out, as they do, the natural inclinations, habits, and,

above all, the more or less elevated degree of sensibility and irritability, and even the physical and moral dispositions of man. The predominance of any one humour over the others may occasion this or that disease, but it is not in its power to show the habits, inclinations, and degree of sensibility of the human body. In short, the animal humours, which are destitute of vitality, sensibility, and irritability, cannot in any way produce the temperaments, which are so many immediate effects of the organization. Besides, which organ is it that produces the black bile, and which, the melancholic humour? Finally, does any one now maintain that most ridiculous of all absurdities; viz., that the spleen is the cause of animal sensitiveness, venereal desire, sleep, laughter, heat, and melancholy? Is not the other opinion also purely arbitrary; viz., that the spleen serves as a counterpoise to the liver, in order to preserve the equilibrium of the two hypochondria, and that it secretes the atrabiliarious humour? And if neither the atrabiliarious nor the melancholic humours exist in nature, how is it, then, that these temperaments still maintain their ground? The specific sensibility of man, which arises from the peculiar dispositions of his organization, is

that which gives the character to his temperament, or rather, to his physical constitution ; it is not, therefore, the mixture, combination, or peculiar disposition of his humours, a phrase completely devoid of meaning.

Is not the plethora itself, which, in the opinion of modern practitioners, generally determines, in the human body, the sanguineous temperament, an effect of the energy of the assimilatory functions, and therefore of the organs which produce it in plentiful quantity ? And why not, then, derive the sanguineous temperament from the organic dispositions of the body, rather than from the quantity of blood, which is scarcely an effect of it ? And are not, likewise, the other false theories derived from these ; viz., those of certain physicians who still speak of the phlogistic state of the blood, and of its igneous and alkaline particles, in order to account for the ephemeral plethoric fevers, as does Sauvages in his *Nosologia* ? Is not, likewise, the abstract and strange division which Bianchi makes, in his *historia hepatica*, of inflammations of the liver into warm or bilious sanguineous, into cold or bilious serous, and into mixed, or compounded of warm and cold, a result of those erroneous ideas formed by so many physicians upon the subject of temperaments ?

Now, admitting, what in our opinion is perfectly just, that temperament properly so called does not differ from the peculiar or natural dispositions of the organic tissue of man; there results from this the further necessity of admitting in nature as many temperaments as there are individuals of the human race; the justness of this deduction is at least borne out by the variety of physiognomies and the diversity of human inclinations; phenomena which certainly would not occur, nor exist, if the natural dispositions, or peculiar modifications of the organization of one individual were not different from those of another. Totally opposite, therefore, to this arrangement of things is the arbitrary reduction of so many temperaments to four only, as if nature had not formed so many individuals, and not classes of individuals.

But whilst we notice the inconsistency of reducing all temperaments to four only, we do not hesitate, at the same time, to observe that the labour of examining all the different temperaments one by one would be infinite; the actual state of medical science, and the limits we have prescribed to ourselves, do not allow us to plunge into the immensity of this subject. It will be sufficient, for the present, to avoid the old error of admitting the humoral

temperaments, or of reducing them, as has been done, to only four. Now the only means, which science suggests to man, to avoid losing himself in the immensity of this subject on the one hand, and not falling into the ancient error, before mentioned, on the other; is that of following the guidance of the more or less elevated degree of the intrinsic properties of life which determine the physical character of man, and of arranging, according to this rule, all the temperaments into so many classes. The sensibility and irritability, in whose exercise consists almost the whole of life, as we invariably meet with them in all animals, even in the last species of the animal kingdom, are, in fact, the intrinsic properties of life.

Thus far is certain, that sensibility and irritability express, the former, the common feeling of the whole body, and the latter, the partial feeling; that both vary in degree, intensity, and energy, in the different individuals of the human species, and that from their various degrees of elevation, energy, and intensity, proceed the different temperaments. Every one, in fact, can distinguish the temperament of a female from that of man; but all the difference of their temperament is re-

duced, in the last analysis, to the sole circumstance, in other respects essential, that the body of the female is more sensible and irritable than that of man. “*Les tempéramens,*” says Fouquet, “*ne sont fondés que sur le plus ou le moins de ressort d’action ou de sensibilité qu’ont certains organes.*”* Boerhaave, likewise, remarks, that the temperaments vary as the strength of the solids and their degrees of irritability vary in the individuals. Haller also derives the different temperaments from the greatness, strength, and various degree of irritability of the heart. Without stopping to remark upon the merits of the origin assigned to the different temperaments by the above-mentioned learned writers, it is certain, that they begin by saying that the temperaments ought to result from the various dispositions of the solids, and not from the peculiar combinations of the fluids, although the same writers had erroneously circumscribed the varieties, some within the sensibility, greater or less, of certain, and not of all the organs, as Fouquet does; others in the strength of the solids, and in their degree of irritability, as Boerhaave; and others again in the greatness

* Fouquet, *Op. cit.* p. 68.

and strength of the heart, and in its different degree of irritability, like Haller, as if the merit, whatever it be, of the heart, of certain organs, or of the sensibility of the solids, could alone embrace and comprehend the condition and state of the vital qualities of all the other organs of man, who is an identical being, every part of whom is sensible, living, and more or less excitable, and it is the specific excitability of all the organs of man, arising from the natural modifications of his organization, which correctly distinguishes and determines the various and real temperaments.

Following, in fact, the law of the various modes of feeling of the different individuals of the human species, as we propose doing; it is our intention to discover and establish the variety of the temperaments in the more or less elevated activity of the various organs and systems, or, which is the same, in their various degrees of sensibility and irritability; in this manner, while we obtain an opportunity of observing, as the results of their elevation, the vivacity of the passions, the energy of the vital motions, and the moral character, which in a great measure depends upon that energy; we are also enabled to discover, at the same time, that the different temperaments originate

in the various dispositions of the general organization, and exactly correspond with the specific excitability, or the various degree and mode of feeling, of the individuals of the human species.

The peculiar dispositions of the organization are so united with the state of man's sensibility and irritability, that the degree of these vital properties may be approximately obtained from the mere external conformation of the body. Thus, in proportion as an individual is fat or lean, robust or delicate, moderately fat, or moderately robust, the mode or degree of feeling of that person will certainly vary according to the apparent disposition of his or her organization. The fatter a person is, and the more bulky his body, the lower in proportion is the sphere of activity of his organs, which therefore are less susceptible of the shock of stimuli, and perform their functions slowly; not only does the animal fat hinder the stimuli from acting directly upon the nervous system, which, together with the sanguineous system, is covered by it, but it likewise represses, and stifles its developement, if it does not paralyze its strength: Nature has, therefore, well marked the class of fat individuals, who have but little sensibility and

irritability; they are also in general scantily furnished with blood, excitement, and physical strength, and especially with energy. Thus, when height is found united with fatness and bulkiness of body, we have the better reason for supposing the individuals of this class to be possessed of little sensibility and irritability.

The other distinct class of individuals, in whom the degree of sensibility and irritability varies according to the external conformation of the body, is that of thin, lean, and emaciated persons: these, as is well known, have a constitution evidently nervous, the more so, as their nerves are large, and more exposed to the action of stimuli, and not at all kept down by animal fat; their organs are in general of smaller size, their operations consequently are more energetic: hence, however small may be the physical force of lean persons, we find in them the elevation of sensibility, and especially of irritability, the activity of their organs, and the energy of their functions. Another striking observation which we shall bring forward, as a line of demarcation between the classes of fat and lean persons, is that the former, whilst they abound, as before said, in animal fat, have but little

blood; the latter on the contrary, abound in blood, and are deficient in animal fat.

Fat and blood are never found together in large quantities in animals; an inverse ratio exists between them; for, two young animals of the same species being bled to death, one of which had been fattened by large quantities of its favorite food, and the other regularly fed, it was observed, after the death of the two animals, that the fatter had less blood than the lean one. It should also be remarked, that this experiment boasts a very ancient date, for Aristotle says in his history of animals: “*Exanguis enim pinguescit, et pinguiora fiunt animantia quibus minus fiet sanguis.*”* Pliny also says the same in different words: “*Obesis,*” observes he, “*minus copiosus sanguis, quoniam assumitur pinguedine.*”† Now who does not perceive at first sight how much more conformable with the improvement of practical medicine is this mode of viewing the temperaments? And of how many modifications is not the plan of cure susceptible, in proportion as it is directed in the treatment of the diseases of fat or lean

* See Aristot. hist. animal. Lib. iii. c. 14.

† See Plin. p. 303.

persons, even when their affections or diseases are of the same character?

And following the same law of the external conformation of man, which cannot but correspond with the internal dispositions of his organization; we find in the solidity, consistency, and thickness of the tissue of robust, strong and lusty individuals, the character of a third class of temperaments visibly different from those of the first and second classes. Robust persons are moderately sensible, and moderately irritable; they possess much physical force, and much blood, and have less energy than lean individuals.

Persons of a slender, delicate and weak constitution, may be comprised in a fourth class: the fragility of their tissue is such, that the lightest stimulants raise the sphere of their vitality as much as they are susceptible of; in other respects, they have but little physical force, little energy and little excitement, or at most, these occur in them in certain cases for an instant only, their frail constitution being incapable of receiving and preserving the continuation of them for a longer time.

The intermediate individuals between fat and lean persons, and those who intervene

between robust and delicate ones, may be comprised in two other secondary classes ; the whole difficulty consists in seeing, by the apparent and external dispositions of their organization, if the individual of the fifth or sixth class approximates more to fat than to lean persons, or more to robust than to delicate subjects and *vice versa*; and according to this rule to form an opinion of their different degrees of sensibility and irritability, and consequently of the merit, or character of their temperament, which exactly corresponds with them.

Two observations, one more luminous than the other, confirm us in the justice of the above-mentioned reform of temperaments; viz., the seeing a variation take place in the temperament which has been given by nature, in proportion as our organization becomes modified or altered, especially by the influence of different climates, which certainly do not act upon the atrabiliarious, phlegmatic, and melancholic humours, &c. ; and the observation that the pulse also varies, in proportion as the temperaments vary: these observations could not be made, if the temperaments really resulted from the peculiar constitution of the humours, as is pretended, at the moment when

any thing beside the humours causes the pulse to beat, and governs its course and variations; variations upon which the true and various temperaments have also a particular influence.

“*Temperamenti magna ad pulsum mutandum potestas est,*” says Albert Haller, “*et rectius quidem diceremus, cor aliter, et aliter magnum, robustum, irritabile, et temperamenta diversa facere, et alios pulsum numeros.*”*

In fact, observation shows that all individuals to whom a yielding, fat or adipose constitution has been allotted, have, more or less in proportion, a close, deep, slow, and small pulse, and its closeness, depth, and smallness, is always proportioned to the small degree of energy of their organs, and especially of the system of circulation of the blood: besides the asthenic state, or natural slowness of all their functions, an effect of the greater bulk of their body, two physical causes also concur in producing the above-mentioned pulse; the thickness of the cellular tissue, which interposes between the artery and the fingers of the observer, and the depth of the artery itself, which, on account of these physical causes, can neither beat freely, nor sensibly manifest

* Haller, Op. cit. p. 262.

its pulsations. It is also known, that fat and corpulent individuals have little sensibility and irritability ; therefore they are not excited by stimuli in proportion to their efficacy, and this circumstance, on the other hand, contributes to the natural depth, smallness, and slowness of their pulse.

Quite opposite to this is the natural pulse of individuals of spare habit : in them it is, in fact, quick, energetic, moderately full and developed, and rather hard. In this effect, there not only concur, the vital actions, which, being set in motion by their nervous constitution, accelerate the movements of the heart and arteries ; but also the plethora, which most frequently predominates there, and the rigidity of the fibres of their tissue. Moreover, it is known how sensible the individuals of this class are to the action of stimuli, and how great is their irritability ; how developed their arteries are, and, finally, with what activity they perform their functions.

The energy and celerity of the pulse of persons of a thin and nervous constitution is supplied, in those who are strong and robust, by the force and vehemence of its beatings ; and their force, fulness, equality, and flexibility exactly correspond to the degree of

their robustness. In robust persons all the organic functions are performed with great intensity, and the first among these is the circulation of the blood, which gives a tone to the pulse that characterizes them.

On the contrary, persons of a thin and delicate constitution have a weak, small, and quick pulse: such individuals are subjected by nature to a mode of life which is characterized by the languor of their functions; whence it naturally follows, that the pulse which directly depends upon them is weak, small, soft, and quick. We shall see, in its proper place, the reason why the celerity of the pulse is very often derived from the state of debility. But it is here necessary to insist upon the importance of the truth before mentioned; viz., that the natural pulse of man varies as the temperaments vary, so that, *mutatis mutandis*, it may well be affirmed, that in the mirror of the pulse are to be observed the degree of intensity of every motion, and the condition and state of organic, vegetative or internal life, a truth which may be turned to no small advantage in the exercise of practical medicine.

Thus, by the new method of deducing from the organic dispositions of man, the more or

less elevated degree of sensibility and irritability, and from this the different temperaments: by this new method, I repeat, we may likewise be enabled to discover the natural character of the pulse, not less of individuals belonging to the fifth, than of those who appertain to the sixth secondary class; classes which comprehend, as before observed, the intermediate individuals between fat and lean, and between strong and weak persons; the proportional medium between the pulses of these indicates, as well in the first, as in the second of these classes, what the natural pulse should be.

From the manner, therefore, in which all individuals of the human race are externally constructed, it may be more or less conjectured what is their temperament, their pulse, the bent of their inclinations, and even, if I may be permitted the expression, the *image* of the diseases which threaten, and will eventually destroy them, unless their appearance be previously stifled, or extinguished by some sinister or sudden misfortune; which caused the learned Dr. Pitcairn to observe, with much justice, that the temperaments are so many natural diseases, the germs of which remain inactive in the organization of different individuals, until they are set in action by the influence

of one or more hurtful causes. Fouquet, likewise, expresses the same opinion, when he says : “ Notre vie est un tissu d’incommodités, “ nos tempéramens même ne sont qu’un état “ d’indisposition habituelle, une sorte d’exis- “ tence malade que l’art de l’éducation et “ une multitude de circonstances ont gravée, “ pour ainsi dire, dans nos organes.”*

* Fouquet, *Op. cit.* p. 73.

ART. IX.

OF THE VARIATIONS WHICH THE NATURAL PULSE UNDERGOES IN INDIVIDUALS OF EITHER SEX, OF EVERY AGE, TEMPERAMENT, AND CONDITION, DURING THE ACTION OF THE SIX NON-NATURAL THINGS, CALLED BY MODERN PHYSICIANS STIMULI, OR EXCITING CAUSES.

THE name of stimulus is given to whatever excites, modifies, and alters the intrinsic property of the organization, or in other words, the vitality. All stimuli may be included within two classes; the first comprises the internal, and the second, the external stimuli: to the former are to be referred the passions, sensations, and partial actions of the organs of internal and external, or animal life; to the latter, the external objects which surround man on all sides; such as the different climates, the various seasons, clothes, food, medicines, blood, the secondary humours, &c., &c.

OF THE VARIATIONS OF THE NATURAL PULSE ARISING FROM THE INFLUENCE OF DIFFERENT PASSIONS.

The celebrated naturalist Buffon has considered human life, in the state of sleep, as the vegetation of a plant; and we will here hazard the assertion already advanced by us in another

work, that man would be in every respect similar to a plant, even in a waking state, had nature deprived him of desires and passions.* The passions, in fact, are born and extinguished with life: when the passions are governed by the salutary restraints of reason, and directed by the practice of virtue to the good of society, they conduct man to the highest degree of dignity of which his nature is capable: but on the contrary, when this curb is wanting, they sink him to the lowest degree of degradation. To ensure happiness, we have but to adopt the wise resolution of subjecting the passions to the authority and direction of right reason, and never the latter to the attractions and seductions of the former. For, besides the moral evils, the immediate effects of the irregularities of the passions, many other physical disorders are likewise the consequence, when they exceed the limits of moderation, or are directed by depraved motives. By following the variations of the pulse which are produced by the exercise of different passions, we shall have an opportunity of being convinced of this truth.

Frederic Hoffman, who has closely studied

* Rucco, *Recherches sur la prolongation de la vie*, p. 97. Paris, 1812 & 13.

the effects of emotions of the mind, says, "that when these are violent, they produce great changes in the features of the face, giving them an unnatural appearance," changes, I say, which are necessary to be observed in practice, because they correspond to those of the circulation and of the pulse, and depend not only upon the state of the vital powers, which may be at one time depressed, and at another elevated, but also upon the agitation of the various plexi destined to the exercise of organic or vegetative life: the more intense and visible are the changes of the above features and of the pulse, the more energetic in proportion should be the exercise of various passions which cause them, and the more elevated the sensibility of internal organs upon which the passions exert all their power. "Aucune affection morale," observes the learned Corvisart "ne peut être éprouvée, sans que le mouvement du cœur soit accéléré, ralenti, ou troublé."*

In the first place, it may be remarked, that although females are more sensible than men, and it appears that they should there-

* Corvisart, *Essai sur les maladies et les lésions organiques du cœur*, etc. p. 371.

fore feel more deeply and strongly the impulse of various passions, the contrary nevertheless is the case, the frail structure of their organs not being capable of receiving strong, deep, and durable impressions: women, by a law of provident nature, scarcely ever openly abandon themselves to the impetuosity of the passions; this at least is the result of observation: with the difference, that whilst the passions are not in general strong in women, they nevertheless insinuate themselves with the same facility that they become extinguished, and disappear. This effect likewise arises from the softness and fragility of their nervous fibres, which are obedient to the slightest moral stimulus; but they cannot sustain either its impetuosity or its strong and profound impression when made upon them. This is the reason why the pulse of females easily varies in consequence of the exercise of any slight passion, and why those variations suddenly disappear, the producing cause ceasing, so to speak, almost instantaneously.

Nearly the same phenomenon is observed in males of a slender, effeminate, and delicate constitution, especially in their youth; for we see that their tastes, moral character, and great sensibility do not differ greatly from

those of women; I say, greatly, because, besides a certain physical difference, which determines their limits, there likewise concurs, in equal circumstances, the difference of education, which does not fail to increase in males the effects of the same passions: hence the variations of the pulse of males are always more sensible and durable than those of the pulse of females, when both are affected by the same passions.

The passions, whatever be their nature, all act immediately upon the heart, and consequently upon the system of the circulation of the blood, and upon the pulse. The sensorial organs are certainly those which receive the various impressions from external objects, conveying them to the brain, or common sensorium, in which they are perceived; but it is not, likewise, less true, that neither the brain nor the sensorial organs directly participate in the effects of the passions. The sensorial organs, in other words, are the direct agents which convey to the common sensorium the various impressions, causes of the passions; and it is the common sensorium, a centre of every species of sensation, which perceives them: but, notwithstanding that the sensory organs and the sensorium are the manufactu-

ners, so to speak, the former of the impressions, and the latter of the sensations in which the passions originate, yet these have not any direct influence, either upon the brain or the sensorial organs: for we see that the one, as well as the others, are free from the affections impressed by the passions upon the excitability of the organs of internal life, the sole seat of the local disorders resulting from them, although it often happens that the effects of different passions sympathetically excite the brain and the sensorial organs. The most celebrated actors, says Bichat, when they wish to express the passions of love, joy, vengeance, sorrow, &c., do not place the hand upon the head but upon the region of the heart, the stomach, the liver, the pancreas, or the intestines, according to the passion they are desirous of expressing. We may now proceed to investigate the relations which unite the variations of the pulse with the exercise of the human passions.

Thus, hope, a pleasing passion, and constant friend of man; ambition, which often leads the mind to its greatest elevation; courage, the mover of great enterprises; joy, and other similar passions, when moderate, and directed by noble motives, raise the energy of the contractions of the heart and arteries;

accelerate in due proportion the course of the blood in the capillary vessels of the cutaneous organ, from which results the animated tint of the physiognomy and external covering of the body; facilitate and develop the exercise of respiration; improve the state of digestion, nutrition, and of the various secretions, which are then performed in a healthy manner; and in this way the above passions render the beatings of the pulse regular, energetic, strong, and robust, and also the lineaments of the face proportionably animated and expressive, which all correspond to the energy of vital motions, and therefore to the elevation of the circulation of the blood. From what has been said, it is therefore clear, that it is upon the organs of internal life, that the above-mentioned passions direct their action, and that, by the effects resulting from them, they merit the appellation of tonic or sthenic passions: in opposition to fear, sorrow, terror, displeasing sensations, &c., which are called asthenic, or depressing passions.

These last-named passions act in quite an opposite manner to the former, for their effects are indicated by the weakness of the organs of digestion, and by the slowness of the vital motions. This state of languor of

the nervous and sanguineous system prevents the blood from reaching the capillaries, and gives rise to the other phenomenon of the paleness of the face, and of all the external covering of the body. The vital powers being depressed, exhibit cold sweats, tremours, palpitations, syncope, and not seldom even death itself, in consequence of the great progress made by the deterioration of the vital powers of the heart, which successively slackens its contractions, and suspends, or finally interrupts their exercise, thus occasioning death. The smallness, weakness, rarity, and often the intermittence of the pulse, which obtains during the action of depressing passions, are therefore the effect of a languid state of the ventricles of the heart and arteries; upon which these passions exert their action and power; and as the smallness, weakness, slowness, and intermittency of the pulse are observed to increase; the greater must be considered the intensity of depressing passions, and the degree of prostration of the vital powers. Such is at least the result of observation.

But although fear, sadness, and the other asthenic passions, act in an inverse sense to those of joy, courage, ambition, and love; yet, when these invade man suddenly, with

great impetuosity, they either extinguish life immediately, as the history of man testifies, or expose it to serious diseases; diseases which, in the last analysis, do not appear different from those resulting from the asthenical passions, which exhaust life directly, whilst the others produce the same effect indirectly.

Commencing, in fact, to treat of joy, we observe in nature, that this passion, when it is intense or excessive, never fails to produce the following phenomena. First, joy shows itself in the countenance, which it tinges with red; then the heart palpitates precipitately, instead of contracting itself regularly; the pulse, of course, becomes agitated, beating more and more irregularly, while tears drop from the eyes; these phenomena are often succeeded by spasm of the heart, and this fatal effect of sudden and excessive joy no longer allows the venous blood to penetrate freely into the right cavities of the heart, in order to pass by this means to the lungs, where it acquires from the inspired air the principles of vitality, which it has afterwards to distribute to the different organs of the human body; a sensation of contraction then generally compresses the epigastric plexus, and the harbingers of death make their appearance; these are, fainting

fits, the intermittence, if not total want of pulse, preceded by tremours in the extremities of the body, paleness of visage, and cold perspiration. All these phenomena, as well as the death by which they are succeeded, result from the exhaustion of vitality produced by the impetuosity of excessive joy.

Ambition, also, when immoderate, is the cause of many physical evils. It plunges the mind into a perpetual agitation; for even should the insatiably-ambitious man obtain the object so much desired, he does not enjoy it, because that very instant he is ambitious of something else; and thus, from desire to desire, he at length passes to a state of deep melancholy; man not being able, by a wise ordination of Providence, to attain every thing in this vale of tears: then jealousy, envy, and hatred combine together, and these base feelings, which certainly degrade man, sensibly affect the exercise of the organic functions. The heart and arteries contract irregularly, and thus the pulse of the ambitious man varies every instant: at one time it beats quickly, at another slowly; now it is hard and deep, and now close, unequal, and often intermittent. The cause of this irregularity in the contractions of the heart and arteries is found in the

depression of the sensitive powers, which produces, in the excessively-ambitious man, that continual agitation of mind which is its consequence.

In like manner, courage, when carried beyond the limits of moderation, alters the course of the blood, and causes a sensible variation in the pulse. Courage, as is well known, arises from a conviction of the strength, which is relative to the energy of the contractions of the heart. The larger and stronger the heart is, comparatively to the other parts of the body, and the more powerfully this organ drives the blood into the arteries, the greater, in general, is the courage resulting from it. But when the courageous man abuses this physical quality, concentrating all his powers in the heart, and therefore in the system of the circulation of the blood, in order to increase their motions, there must, of necessity, this evil ensue, that the system of the circulation of the blood passes from an excess of strength and activity to that of depression; a transit which corresponds to the principle of the physicians of the mechanical sect: *a summo tono laxitas*. The strength of the heart and arteries, by excess of exercise, slackens, and the whole system of the circulation falls into a like debility; a de-

bility which Brown designates as indirect. The prostration of the vital powers of the heart causes the contractions of its ventricles to be languid, slow, and uncertain, and consequently the pulse to be small, weak, deep, unequal, and often intermittent; and instead of being energetic, strong, full and robust, as it is found to be in a man moderately courageous, it becomes the index of the state of depression and prostration of the organic functions when this passion is exercised beyond the limits of moderation.

Equally fatal are the effects produced upon man by impetuous love. Whether the passion, thus intense, be caused by physical wants, or whether it is inflamed by a heated imagination; in both cases, either the man possesses the beloved object with delight, or ardently desires to possess it: in the first case, he is always in a state of excitement from its presence, which does not fail to inflame him more and more; and the fear of losing it, whilst it is in his possession, joined to the ardour which he feels in approaching it, are both of them continual stimuli, which keep him in a state of orgasm. The heart palpitates, instead of oscillating regularly; the arteries, which follow its direction, contract themselves imper-

fectly, and the pulse cannot then but be agitated, quick, and unequal, and subsequently becomes small, slow, close, weak, deep, and not unfrequently intermittent.

And, in the second case, that in which the person does not possess the beloved object with transport, whilst he ardently desires to possess it; in this second case the effects are still more alarming. The beloved object who is absent, or withheld from him, keeps the lover in a state of continual internal tumult, which gradually consumes and exhausts the vital powers, and at length plunges him into a state of deep depression: hence, from the state of prostration of the vital powers of the heart arises the irregularity of its contractions, and hence the smallness, deepness, rarity, and inequality of the pulse, which is often confounded with the intermittency of its beats; and such is the prostration of the organic functions in some young and despairing lovers, who have been deprived of the beloved object, that it requires the most profound sagacity of a skilful and consummate physician, not to confound this deplorable state of life with other severer and more dangerous diseases. And to how many fatal disorders are not patients of this description ex-

posed, when their case is intrusted to a person who is not sufficiently versed in the study of the human passions!

During the act of sexual intercourse the pulse varies sensibly, according as the impulse which causes it arises from physical wants, or from sympathy and nervous influence: in the first case, the pulse does not exhibit so many variations as in the second. The act of coition sets the nervous action in orgasm, which, in its turn, sets in motion the organs of generation, exciting the system of the circulation of the blood, and consequently increasing the force and energy of the motions of the heart and arteries, and thus communicates to the pulses of both sexes the acceleration, or febrile motion, which characterizes the venereal act: the pulse is then, in fact, energetic, agitated, vibratory, and quick, and its energy, agitation, vibration, and celerity, correspond with the orgasm of the nervous action, and with the energy of the contractions of the ventricles of the heart. After the venereal act, when the nervous power ceases to perform its office, general weakness succeeds the effect of the convulsive motions, and loss of the vital fluid which nature replaces at the expense of the other organs: the heart then oscillates without

energy, and without strength, and from the languor of its contractions, arises the cause of the pulse being weak, small, close and slow, after coition. All animals remain languid and weak after copulation, and the prostration of their strength combines with the duration of the orgasm, or convulsive motion.

The passion which is hurtful to man, even when moderately indulged, is anger, rage, disdain, or desperation: anger, besides degrading man, in as much as it is the effect of ignoble and base feelings, likewise changes his constitution and health. In the strong exercise of this brutal passion, a more or less tumultuous and rapid internal movement is generated, which spreads itself especially over the vascular sanguineous system: for this reason the heart redoubles and multiplies its efforts, whilst it performs, as expeditiously as possible, its rapid and strong contractions, from which arise the accelerated course of the blood and of the beatings of the pulse: to this mode of existence of the system of the circulation of the blood corresponds the then active exercise of respiration; because the lungs also multiply the number of inspirations within a given time; the contractions of the muscles of the face exhibit in the physiognomy the image

of a state of convulsion, not less violent than alarming; the natural heat of the body is increased, the face becomes red, and afterwards livid; the pulse beats with vehemence and rapidity, and its oscillations are sensibly hard. All these phenomena, which show the state of violence to which choleric men expose themselves in the exercise of their passion, endanger life sufficiently to convince us of the malignant character of anger; thus, should this passion not be intense and strong enough to exhaust vitality at once, and consequently bring on immediate death, as it frequently does; it may nevertheless induce apoplexy, or ultimately cause organic affections in the heart, the liver, or in the other viscera.

It is a constant phenomenon to see the vital powers fall into a profound depression after a paroxysm of anger; and its constancy is maintained by the loss of the many efforts made by life, when raised to that degree to which it arrives by means of the paroxysm of anger. The rapid and tumultuous motions in which the exercise of anger consists, do not differ from so many convulsive efforts, which, according to the law of the animal economy, must fatigue the organs, and enfeeble the functions: and this general asthenical state

of the body is sensibly indicated by the pulse, which from being vehement, hard, quick, and elevated, as in the first coming on of anger, becomes small, weak, deep, unequal, and often intermittent, after the paroxysm of this more than dangerous passion.

ART. X.

OF THE VARIATIONS OF THE PULSE ARISING FROM
 THE EXERCISE OF THE INTELLECTUAL FUNCTIONS,
 FROM MUSCULAR MOTION, FROM WATCHING,
 FROM SLEEP, FROM THE SECRETIONS AND
 RETENTIONS, ORGANIC FUNCTIONS WHICH
 WE SHALL CONSIDER AS SO MANY STI-
 MULI, OR INTERNAL AGENTS.

THAT the exercise of the intellectual functions belongs exclusively to the brain, in which the soul presides, is allowed by the most distinguished physiologists of Europe: they are not, however, agreed precisely as to the seat of the intellectual principle. The following are our observations upon this point in the work already quoted upon the prolongation of human life. “ Lorsque nous rapportons la
 “ vie animale aux facultés intellectuelles, elle
 “ élève l’homme au-dessus de tous les autres
 “ animaux, par la raison dont elle est la
 “ source. Personne jusqu’à présent n’a con-
 “ tredit cette vérité: cependant tous les écri-
 “ vains ne conviennent point sur le siège du
 “ principe intellectuel. Descartes en suppose
 “ le siège dans la glande pinéale; Vieussens
 “ dans le centre ovale; Bontekoe, dans le

“ corps calleux; Digby, dans le septum lucidum; Willis, dans les corps striés; Drelineurt, dans le cervelet; Molinetti, dans le pont de verole; Haller, dans les corps quadrijumeaux; etc., il faut donc en conclure que la masse du cerveau est le laboratoire de la pensée et la condition matérielle de nos connoissances.”*

The fact that a violent blow upon the head immediately suspends the exercise of the intellectual faculties; that the presence of an abcess in the brain causes the loss of memory, which is another faculty of the mind; that a lymphatic or serous extravasation in the ventricles of that organ annihilates the functions, depriving man of the act of thinking, judging, and reasoning. All these, and various other similar anatomico-pathological observations, sanctioned by practice and experiment, lead us to conclude that the brain must truly be the common sensorium, the seat of the intellectual principle, and the material condition of the human understanding.

Such being the case, it is easy to conceive that the exercise of the intellectual faculties

* Rucco. Recherch. sur la prolongation de la vie, etc. p. 41, 42, 43.

must cause the pulse to vary. Besides, the brain influences, as we shall see further on, the movements of the heart and arteries by means of the mechanical phenomena of the respiration, and the heart directly upon the brain, to which it sends, by its contractions, the red blood, charged with the vital principles; several other practical observations, also, concur on the other hand in showing the relations which exist between the functions of the brain, and those of the heart. Upon this subject we here report the observation respecting convulsions in general, paralysis, and apoplexy, caused by wounds or injuries received in the medullary substance of the brain, and we will notice, at the same time, the disturbance of the contractions of the heart, and consequently of the general system of the circulation of the blood, which constantly results from these disorders, and then, if the presence of the injuries of the medullary substance of the brain alter the functions of the nervous and muscular system, we do not perceive why the same cause should not alter the beating of the heart and arteries, as soon as nature cannot do otherwise.

It will hereafter be shown, that in the state of sleep, in which the functions of the

brain remain inactive, the heart and arteries do not oscillate with such force and energy as in that of waking. And in fact the beating of the pulse varies in proportion as the exercise of the intellectual faculties is increased or diminished; because, when their exercise is raised to a certain point, which is frequently to be seen in extemporaneous poets, and in orators of great eloquence and superior wit, the pulse then beats quickly, and its pulsations are more energetic and agitated. The elevation of the intellectual functions which arises from the inflamed and heated imagination of the extemporaneous poet, or the orator who declaims, sets in orgasm the whole nervous system, and this, which animates with its irradiations the other organs, especially the vascular sanguineous system, cannot but put in activity the contractions of the heart and arteries, and hence arise the variations of the pulse, which, as before stated, becomes quick, elevated, energetic, and agitated, at the moment that the sphere of activity of the perceptibility or sublime sensibility of the brain is raised.

The opposite to this is observed in the pulse, when the exercise of animal life, or of the intellectual faculties, is depressed or slackened; this is the case in certain dull minds, which

vegetate instead of live. The slow use of the mind does not keep the sensory organs in sufficient exercise; the action of the sensitive forces is not properly revived, and consequently does not concur to increase the energy of the system of the circulation of the blood: therefore, in this state of vegetation, the pulse must necessarily be slow, small, and rather weak, unless other physical causes, arising from the energy of the organic life, tend to the improvement of the pulse; because, in this state of stupefaction, imbecility or depression of the sphere of activity of animal life, the pulse cannot perform its pulsations with energy, strength, and celerity.

The other variation of the pulse which is observed by means of the animal life, does not materially differ from that which obtains in individuals whose minds are but little exercised, although resulting from a cause wholly different. A similar variation is observed in the pulse of those who abuse the exercise of the intellectual faculties; for, when the chord of excitement of the brain is stretched beyond its due tension, as occurs in persons greedy after knowledge, who desperately, and without interruption, give themselves up to the study of an art or science; when this is the

case, all the living system becomes weakened; the heart likewise contracts and dilates slowly and languidly; the course of the circulation of the blood is performed in an equally feeble manner, and hence, the pulse becomes small, weak, and slow; a phenomenon coinciding with the depression of the vital powers, the effect of the long, continued, and profound exercise of the mind.

According to Fernel, the abuse of animal life may occasion catalepsy, or the sudden privation of sense and motion, followed by the flexibility of the trunk and members, and by a species of automatic tension of the muscles. The nature of this alarming affection permits, in fact, the body of the patient to take any position to which it may be subjected, to such a degree can the exercise of the mind alter the physical constitution and the sensitive forces.

Conformably to the same law, pointed out in the variations of the pulse, arising from the exercise of the intellectual faculties, proceed likewise the variations which the pulse experiences during and after the exercises of the body; for we see that the pulse does in fact vary, according to the method followed by man in exercising his muscles, and ac-

cording to the duration of their action. We have already seen that corporeal exercise increases the robustness of the muscles; restores strength debilitated by long repose, and prolongs the usual tone of life, when the exercise of the body is moderate, and conformable to the age, sex, and character of the physical constitution, to the climate, habits, and especially to the state of the individual strength. When man is in this happy state, not only are the contractions of the heart improved by the influence of the free and vital air which is respired during a change of place, but in the course of the exercise of the body, the improvement of the vital powers, which is obtained from it, concurs also in their energy. Now it is the concurrence of these favourable circumstances which permits the heart and arteries to execute fully and freely their contractions and dilatations, and produces a developed, elevated, flexible, and equal pulse, such a pulse as is found from the salutary effects experienced by man during and after the moderate exercise of the body.

But the pulse varies, growing worse in the extremes; because, whether man exceeds the limits of moderate exercise, or leads a se-

dentary life, in both cases the pulse ceases to be equal, flexible, elevated, developed, and free, such as is observed in adults enjoying the best health, who do not neglect corporeal exercise: on the contrary, in the excessive exercise of the body, it becomes rapid, tempestuous, violent and irregular, as may be seen in the case of grotesque dancers, runners, blacksmiths, and all such as are engaged in violent or fatiguing labours. In the course of such bodily exercises and labours, the fact is always to be observed, that the columns of blood crowd precipitately into the ventricles of the heart, which, in order to disembararrass themselves of this accumulation of blood, are compelled to repeat their contractions with like frequency; and they repeat them with a sensible impetus, as if they were irritated, so to speak, with the quick return of the blood, which incommodes them; and from this state of violence of the ventricles of the heart, and vascular sanguineous system, is derived the rapidity, agitation, vehemence and disorder of the beatings of the pulse, which characterize the irregular and violent exercises of the body. Sometimes those exercises of the body are so violent and strong, and consequently the course of the blood so

rapid, that the violence of this fluid at length paralyzes the fibres of the heart, and therefore exposes those who exercise their muscles with too much violence, thus exceeding the limits of their strength, and outraging nature, who does not allow them thus to act with impunity, to the most serious diseases. Only the habit gradually acquired by dancers, runners, smiths, and others, can prevent their being so frequently subjected to the disorders which they ought otherwise to expect.

To the state of excessive violence of the organic functions, by reason of the violent and rapid movements of the body, necessarily succeeds the debilitation of the vital powers, since the effects of the strength of the body have their limits, and the pulse, which always follows its law and progress, indicates, in fact, the state of depression and languor, by the smallness, weakness, depth and inequality of its beatings, according to the result of practical observation.

Not less injurious to the human body are the effects produced by a sedentary life, because daily experience proves that the want of regular bodily exercise weakens, negatively, the vital powers: I say negatively; because, with repose, the phenomenon of life is denied the

influence of a stimulus which preserves its robustness, energy and duration, as the muscular action does by the exercise of the body : this truth is confirmed by the observation of the pulse, which never fails to appear, more or less, weak, small, slow, soft and rare, such as it is indeed observed in persons who avoid the regular exercise of the body, and who pass their days slothfully in bed, or in a state of inaction.

An effect contrary to that of a sedentary life is observable in the different mode of living which prevails among country-people : these, while they breathe a freer and better-oxygenated air in the fields which they cultivate, acquire, by labour and bodily exercise, a strong and robust complexion : their labour being neither violent nor excessive, their body develops itself perfectly, and increases in strength, by favour of the habit of labour, which keeps the organs exercised, and strengthens them more and more. All things concur, in countrymen, the salubrity of the air, the placidity of their passions, the regularity of digestion, and the healthy exercise of the body, to the free and complete contraction and dilatation of the ventricles of the heart and arteries, whence result the fulness, vehemence, hard-

ness and freedom of the beatings of the pulse, which characterize them. Thus, in the more extended sense, it is not difficult in practice to judge from the kind of work, art or profession of an individual, what should be nearly the state of the sanguineous circulation and of the pulse, and *vice versa*.

And it is not a small advantage in practice, to inform one's self of the daily occupation of patients when in a state of health, because the character of the morbid pulse should be appreciated by the value of the natural one. If the question be the kind of work or occupation of three individuals of the same age, sex and constitution, the degree of intensity (in case of illness) of their disease may be judged, by a knowledge of their different occupations in a state of health; because, supposing that to be the case, which is not seldom found among persons afflicted with acute disorders, received into hospitals appropriated to diseases of that kind, that the pulse is more or less equally changed; that is, equally strong, quick, vehement and hard; under this supposition, is it not clear that the disorder must be more intense and severe in the individual who has less exercised his body in a state of health? Hence it follows, that the want of strength, vehe-

mence, celerity and hardness of the natural pulse of this individual is necessarily supplied by the morbid strength, vehemence, celerity and hardness, which would be the effect of the greater intensity and severity of the disease.

Thirdly, the natural pulse of man varies in proportion to the watching and sleep. In the waking state, all the organs of life are in a state of activity, from the brain to the smallest part of the body; and nothing is to be observed, during this state, but a series of phenomena which succeed each other in regular order, all conducing to one sole object. The state of waking is especially indicated by the exercise of the functions of the sensorial organs; of the brain, the vocal organs, and of the voluntary muscles, which represent the most active part of it. It is therefore very natural that the phenomena of life should display greater strength and energy when the brain and the intellectual principle exercise in concert the functions of animal life in the course of the waking state, when the senses are excited and stimulated by the action of external objects, and when, finally, the organ of the voice and the voluntary muscles execute by their motions the desires of the soul. Now, this degree of activity, of action or develop-

ment of strength and energy, which is perceived in a state of waking, is the same which elevates the sphere of the movements of the internal or vegetative life ; which increases the general excitement ; strengthens and accelerates the contractions and dilatations of the heart, and, in like manner, produces the quick, elevated, energetic and flexible pulse, which is in fact found in the state of waking.

Now, two circumstances may deteriorate the pulse during watching ; the one is when its duration is prolonged beyond the proper time, and the other when it is too much shortened ; because in both cases, the pulse is generally found small, weak, and slow ; with this difference, that its slowness, smallness, and weakness, arise in the latter from an excessive state of repose : with this other peculiarity, that sleep ameliorates the condition of the weak, small and slow pulse which results from the excess of exercise and motion ; and watching does the same, when such a pulse arises from the state of repose prolonged beyond the proper time. In fact, sleep is admirably adapted for restoring the strength worn out and wasted by excess of exercise and motion, excess which is produced by long and protracted watching. The suspension of the exercise of senses,

of the cerebral organ, and of voluntary muscles, in which sleep consists, negatively increases, although, consequently, in a mysterious manner, the perceptibility, general excitability, and muscular irritability; vital properties which, according to observation, are gradually worn out and consumed in the successive course of long and protracted watchings; and by this most simple means nature restores the powers of life, and wonderfully prolongs its course and duration. Therefore, as soon as the organic forces are restored to their former tone by sleep, it reasonably follows that the pulse also reacquires its ordinary strength, energy and quickness, which it usually loses in the course of watching prolonged beyond the limits assigned by nature.

But it is a false position to believe that the pulse always continues to raise and develop itself successively in the course of sleep, when sleep is prolonged beyond the proper time; because when man has finished restoring his strength by a moderate repose, he cannot but weaken himself anew, by continuing to sleep; an inconvenience which is owing to the other excess of immoderately suspending and slackening the exercise of the muscles, of the

sensory organs, and of the brain, an exercise so necessary to the preservation of life. The pulse, therefore, falls into the state of smallness, weakness and slowness, from that of elevation and developement, after the ordinary course of sleep. Thus, the more sleep is unnecessarily prolonged after the recruiting of the strength, the weaker, slower, and smaller becomes the rhythmus of the pulse; because, whoever sleeps beyond the degree indicated by recovery from mental and bodily fatigue, brings on the prostration of his strength, which increases in proportion to the progress of the state of want of energy, and not of inaction, or apparent death, such as is profound sleep.

It is therefore useless to endeavour to maintain, as, among other writers, Morgan and Brown have done, that the celerity of the pulse increases during sleep from 75 to 83, and not seldom to 96; as if, in opposition to the principle not long ago established by us, the repose of the organs of animal life, the inaction of the muscles, and the slackening of the functions of the organic life could be reconciled with the increase of the celerity of the pulse, and as if it were not an absurdity to believe this to be possible. Morgan and Brown were enabled to observe the increase

of the beatings of the pulse during sleep, from causes purely secondary, as in fact happens, when the sweet repose of the night is disturbed by frightful dreams, by slow and difficult digestion, and by the always irritating effects of spirituous liquors, taken in a large dose; but not in the state of perfect sleep. All the above inconveniēces, the offspring of excess in meat and drink of every description, excite in the stomach and the nervous system painful sensations, which do not fail to produce, in their turn, movements quite opposite to the state of health. Irritation, in the course of sleep, is therefore that which changes the movements of the organs; that accelerates the contractions of the heart and arteries, and causes the pulse to be quick, which it would not be without the concurrence of one or more causes purely secondary, similar to those which alter, as I have observed, the natural order of the phenomena of life. But the pulse of an individual who enjoys a regular and tranquil sleep is as different from that of him whose rest is disturbed, as the state of health is different from that of disease.

In support of our opinion, that the celerity of the pulse cannot be directly increased by the influence of sleep, may be adduced the

opinions of two of the first physicians of the last century; viz. Boerhaave and Albert Haller; the former of whom thus expresses himself: "*Pulsus dormientium manifeste tardior, seu lentior est, lentior item respiratio;*" and the other says nearly the same thing in these terms: "*Nam vigilantibus hominibus cibus, et musculorum motus, et animi studium aut adfectus pulsus augent, quæ omnia a dormiente homine absunt.*"

Hence it is manifest, that the pulse is quick, full, elevated, and energetic, in the usual waking state, and slow, small, and weak, or rather less quick, less elevated, and less energetic, in regular sleep. Being always, however, understood, that the pulse, as I have before observed, varies, both in waking and sleeping, in proportion to the improper duration of both. A fact, the knowledge of which no longer allows us to attribute, during the state of disease, all the celerity of the febrile pulse to the sole morbid cause in the state of waking, nor likewise all the smallness, weakness, and slowness of its pulsations to the diseases of languor, in the state of sleep.

Lastly, the retentions and excretions, by virtue of being organic functions or internal stimuli, influence the variations of the pulse. During the retentions, whether of urine, or of

the faecal substances, or of the perspiratory humour, upon which properly the act of suppression takes place, man experiences a state of uneasiness arising from the irritation or inflammation produced by the presence of the excrementitious substances, retained or suppressed in the proper organs or receptacles. The unnatural action of such substances on the organization of man begins to excite the reaction of the organs, and this reaction gradually draws in the nervous action which cannot but render the exercise of the circulation of the blood more active, and consequently the beatings of the pulse, which, in similar cases, assumes the aspect of the febrile pulse, so that the irritation of the substances suppressed or retained accelerates the course of the blood: and when it happens that the continuance of the said substances in the human body is prolonged by other secondary causes, the pulse then acquires a decided degree of hardness, which, united to the agitation, the strength, and celerity of its beats, constitutes, together with these modifications, the distinctive character of the pulse, which announces the retention or the suppression of the natural evacuations.

Weak, small, slow, deep and unequal, on

the contrary, is the pulse, which is caused by excessive evacuations or excretions; these, as they produce the prostration of the vital powers, are the direct cause of the slowness and weakness of the contractions of the heart and arteries, to which the pulse owes the origin of its smallness, deepness and irregularity, as of its slowness and weakness. The blood becomes impoverished, losing by most copious perspirations, by immoderate fluxes of urine and fæces, a great portion of white humours; the body which is thus deprived of its moisture, becomes weaker and weaker, and all the effects of the continued, great loss of humours, still necessary for the nature of the blood, are the cause of that extreme languor which is daily observed in practice, in consequence of the excessive and extraordinary excretions of the body.

ART. XI.

OF THE VARIATIONS WHICH THE NATURAL PULSE
UNDERGOES IN CONSEQUENCE OF THE EFFECT
OF EXTERNAL STIMULANTS.

ALL the bodies by which man is every where surrounded, and which are commonly called stimulants, or external exciting forces, act in an uniform manner upon his vitality, some exercising their power upon the lungs, others upon the liver, some again upon the cutaneous system, and lastly, others upon the stomach, or some other organ or part of his body. The class of external stimulants is divided into three sections; the first comprises all those substances which are destined by nature to supply the most pressing wants of life, for they preserve its existence and duration; these are food both solid and liquid, the air, &c. The second includes the substances which appear to have the power of weakening, neutralizing, or overcoming the greater part of diseases, such are medicines of every description, which, for the above reason, are called remedies, or artificial aids of the medical art, and the third and last section embraces finally the blood with the white or secondary humours:

these, as not forming an integral part of the organization in the fluid state, act upon it more directly, and are the cause of its preservation: on which account, they deserve to be separated from all the other stimulants in a third section. We shall see, in its proper place, the consideration which is due to the stimulus of the blood, and white or secondary humours, as those agents, whose character and various proportions decide every instant the regularities or irregularities of the exercise of life.

In this state of things, the atmospheric air certainly merits the first place in this section, which includes the substances destined to supply the natural wants of life, varied, indeed, but all-important as they are to its existence. The atmospheric air administers the oxygen and caloric to the blood by means of the lungs, and thus revives and animates the exercise of life: it gravitates upon the human body, which it surrounds, and excites its superficies or external covering; and whilst it acts, as we see, specifically upon the excitability of the lungs and cutaneous system, it causes a sensible variation in the pulse according to certain physical circumstances.

First, it must be observed that according as

a person inhabits an elevated or low situation, so the respiration and circulation of the blood are exercised energetically, or tranquilly and slowly, and these functions consequently cause the pulse to be quick and energetic, or slow and rare. The tone of energy, which both these functions, the respiration and circulation of the blood, assume in the more elevated part of the atmosphere, is certainly owing, not less to the necessity which is there experienced, of more frequently repeating the inspirations on account of the rarefaction of the air, than to the greater quantity of oxygen which the blood necessarily receives within a given time; for it is well known that the rarefaction and purity of the atmospheric air increase in proportion to its height from the superficies of the earth: hence the reason is evident why the activity of the system of circulation of the blood, and consequently the celerity of the pulse, are increased in persons living in the more elevated situations of the atmosphere.

And here seems to be the proper place for showing the reason, which forbids a further continuance of the practice, followed by many practitioners, of sending consumptive persons, already advanced in the last stage of the disease, to breathe the country air, or

the air of more elevated southern regions, where, for the reason already shown, the pulse performs its pulsations with celerity and energy; and whilst every physician knows how necessary it is in practice to diminish the excessive celerity of the pulse of consumptive patients by the help of *digitalis purpurea*, in order to prevent by these means the excessive night perspiration, many fall into the inconsistency of sending persons far advanced in this disease to respire, as I before observed, the country air, or that of elevated and southern countries; as if the action of the air, there exceedingly elastic and active, or rarefied, would not increase still more the febrile celerity of the pulse, and were not altogether incompatible with the extreme weakness and fragility of the already-altered tissue of the lungs of consumptive patients. To this may be added another observation; viz., that the suppurations of the tubercles succeed each other with more rapidity by reason of the atmospheric air, which is in such places saturated with oxygen, which in excessive quantity inflames, alters and destroys the tissue of the lungs, which is consumed like any other combustible body, when subjected to the process of a rapid combustion, to which respiration bears no slight resem-

blance. Hence the idea would certainly be strange, of still continuing to believe that the air of elevated places is capable of being advantageous to consumptive persons, already advanced into the last stages of the disease.

It is only in the diathesis of pulmonary phthisis, or at most in its first stage, that the action of elevated, highly-elastic and country air, can be of service, and then only on the supposition that the pulmonary phthisis be not a consequence of the hæmoptysis or hemorrhage of the lungs, which might otherwise again show itself, from the effect of the rarefied and highly-elastic air. And thus it is, that from a knowledge of the effects which exciting forces produce upon the pulse may be, and in fact are, deduced, the rules of prescribing or rejecting them with reason, in either, or both disorders.

Thus, returning from this practical observation, to the effects of the air upon the pulse, we see that its exercise is slackened, and its beats become more rare, when (the opposite of the former case) a person lives in a low situation of the atmosphere; because, whilst this fluid receives and contains within itself a prodigious number of small bodies which are foreign to its composition, and alter its cha-

racter; it is not itself elastic and active to such a degree as to be fit for the wants of life. In short, the scarcity of oxygen, for this is not found in due proportion with azote, in low situations of the atmosphere, and the many small bodies which rise and float under the form of vapours, miasmata or exhalations, both these imperfections of the atmospheric air, when they do not produce some disease, do not fail to render it incapable of reanimating, as may be requisite, the exercise of respiration, circulation of the blood, and consequently the beatings of the pulse, which, with a knowledge of the cause, are observed to be slow, rare and weak, in persons who breathe a low air; an air which is rather serviceable to individuals subject to hæmoptysis or spitting of blood, and which sensibly prolongs the life of consumptive persons.

The other action which the atmospheric air effects upon the pulse, differs not from that of the various climates which surround man on every side, and more or less excite the external covering of his body. This truth arises from the certainty that every climate results from the presence of the atmospheric air, and that it is the different degree of latitude, or the specific temperature of the atmosphere, which

constitutes the variety of climates. By climate geographers mean that tract of earth which lies between two circles parallel to the equator ; but the character of the climate of any region whatsoever certainly varies as much as do its various places and situations throughout the whole of its extent. The reason of this truth may be found in the various high or low situations of the different provinces and departments of a kingdom ; a reason which acquires greater force, when we examine the different effects which the atmosphere, that surrounds the different provinces of a kingdom, produces upon the constitution and pulse of their inhabitants. The proximity of the sea to a country or a city makes an immediate change in its surrounding atmosphere ; and the partial climate of this certainly differs from that of any other country, although of the same kingdom, when the second is near rivers or infectious lakes. The number of climates, therefore, is not confined to seven, as the ancients imagined, nor even to thirty, the number assigned by Varenius, but they are innumerable and infinite.

Others apply the name of climate to every part of the known world which differs from another, as well with respect to persons and the quality

of land, as to the customs of the inhabitants, and the phenomenon of longer days. Whatever may be the merit of this definition, it does not appear sufficient to us, in order to determine the variety of the partial climates, which are certainly contained in any one country or kingdom. It is for physicians who practise the medical art in the different provinces or departments of a kingdom to decide whether practical medicine would be benefited or not, by the observation, contrary to the almost universal rule, of confining one's self to the general ideas only of the climate of a country, without attending to any of the researches which have relation to local peculiarities, and are calculated to exhibit more clearly the climate of every department, province or country of the same kingdom.

As to the object of examining the variations of the natural pulse, which proceed from the action of different climates, it will suffice to recur to the variety of temperature, and the various degrees of natural purity of the atmosphere, a circumstance, in comparison with which all others possess but a secondary influence.

Following this principle, we reduce all the climates of the world into three orders, pre-

serving always intact the rule of becoming acquainted with the peculiarities of the climate of every country of each kingdom, when the intention is to exercise there the medical art: returning, therefore, from this examination, which relates to another branch of the science of diseased man, we confine ourselves to consider the variations which are produced in the pulse by hot, temperate, and cold climates; climates which we comprehend, as I before observed, within three orders.

This threefold classification of the climates is at least justified by the different state of the pulse, which undoubtedly varies in proportion as man inhabits a warm, temperate, or cold climate. The pulse is in fact quick, elevated, and more or less irregular, in the inhabitants of southern climates, where the solar rays fall perpendicularly upon the surrounding horizon, and excite in an extraordinary degree the cutaneous system. The high temperature of the atmosphere which surrounds the inhabitants, and the direct action of the burning rays of the sun, both these stimuli increase the activity of the vital movements of various organs, and thus consequently accelerate the course of the blood along the arteries and

veins, and therefore the beatings of the pulse : and, what should be especially noted is, that the inhabitants of the southern regions, precisely because they were born there, and received there their physical education, are much more irritable and sensible : to all which may be added, the efficacious action of the atmospheric caloric upon their constitution. The caloric concentrates itself at first in the cutaneous system, and thence diffuses itself over all the other organs ; to this series of partial actions directed by the caloric upon the internal organs, corresponds their reaction, which arises from the elevation of their sensibility, an elevation which always increases in succession, and gives rise to that state of general irritation or superficial inflammation, which announces and manifests itself by the rapid contractions and dilatations of the heart and arteries, which give law to the pulse, which performs, in southern climates, as many as one hundred and twenty or more pulsations in the course of a minute. “ *Æstate,*” says Haller, “ *et circa æquatorem, pulsus frequentiores sunt, ad 120 usque. In calida parte orientis pulsus in minuto primo vulgo sunt 100.*”

The zephyrs, however, of the morning and evening, concur with the repose of the night in

seasonably moderating the elevation of the general sensibility, and with it the rapidity of the motions of the heart, arteries and pulse : but this state of apparent inflammation again returns in the hot hours of the day ; and when the inhabitants of these arid climates do not avail themselves of the advantageous effects offered to them by nature in the course of the nocturnal repose, there results the inconvenience, that they more speedily wear out their organs, by dint of an immoderate exercise of them, and at length fall into a profound depression. The tonicity and contractility of the fibres of the heart and arteries lose a great part of their power, and hence arises the other phenomenon, that the heart and arteries can no longer react upon the blood with sufficient force and regularity ; the exercise of the circulation languishes, and the pulse becomes weak, unequal, quick and small, from indirect weakness. In all the southern kingdoms, and in the hot seasons of countries excessively warm, it would be advantageous to introduce the salutary use of a few drops of dulcified sulphuric acid, mixed with water, in which a given quantity of sugar had previously been melted, repeating this drink from time to time in the course of the day, when required by the stimulus of

thirst. Whilst the sulphuric acid lowers the animal temperature, as all acids do generally, this has the peculiar advantage of increasing the tonicity of the fibres of the heart and arteries; of elevating the tone and strength of the body, and of moderating, by this means, the rapidity of the vital movements, which then arises from the depression of the organic vital powers, in consequence of the excessive action of the atmospherical caloric.

But the pulse does not beat with this velocity in the inhabitants of temperate climates, as is also found from practical observation. The equilibrium of the vital powers which is generally found in the just proportion of the stimulants with the sensibility of the inhabitants of temperate climates, is the cause of the moderate celerity of their pulse. Besides, the inhabitants of temperate regions are not so liable to excitement, and so sensible as those who live in southern climates. The temperature of the atmosphere, also, in temperate climates, is not so high as to stimulate the excitability in any extraordinary degree: on the part of the climate, therefore, nothing is wanting which can directly contribute to the equilibrium, the moderate excitement of the various organs, and to the exercise, nei-

thier too slow nor too rapid, of the circulation of the blood, from which is produced a moderately-quick, energetic and developed pulse, such as is observable in the inhabitants of temperate regions.

The pulse of the inhabitants of cold climates differs from that of those of hot and temperate ones. As a sensibly-low temperature predominates in the former, and the cold resulting from it is proportionably severe; so it would be useless to maintain that its influence upon the physical constitution is not such as to slacken the course of the circulation of the blood, and the beats of the pulse. The living beings indigenous to northern climates, as they are born robust, and receive at the same time a physical education, calculated to favour the progress of their natural strength, acquire by this means a strong and athletic constitution; all their exercises and daily occupations tend to reinvigorate their organs, and from this concurrence of physical circumstances results the proportionate tone, which their pulse takes in the plan of life. The ventricles of the heart exercise their contractions with such a force, that they do not feel the necessity of repeating them either with the moderate frequency which is proper to the ven-

tricles of the heart and arteries of inhabitants of temperate climates, nor with the velocity or rapidity of the ventricles of the heart and arteries of inhabitants of southern climates. Now, this is the physical cause of the strong, full, developed, and sensibly-rare pulse, which characterizes the inhabitants of cold countries. Blumenbach observes that the pulse of the Greenlanders is so rare, that it does not perform more than forty beats in the course of a minute. Haller therefore was right in saying, "*Pulsus in universum mensura est. virium, quas cor in promovendo sanguine impendit.*"*

It is therefore an error to suppose that the rare pulse is a constant sign of weakness, and the quick one an indication of strength. In the above-mentioned case of the inhabitants of cold climates, the rarity of the pulse rather indicates strength; because the ventricles of the heart, which, as before observed, drive out the blood with great force, have no necessity for their contractions being repeated with celerity; a celerity which generally supplies the defect of strength in the contractions of the ventricles of the heart and arteries, and which

* See Haller, Op. et loc. cit. p. 247.

is clearly observable in the inhabitants of southern climates, and in other persons attacked by malignant hyposthenical fevers, arising from a profound prostration of the vital powers.

The other remark to be made upon the pulse of the inhabitants of cold climates, relates to the effects of excessive cold, because when it happens, as is often the case, that a very severe cold is experienced in northern countries on account of the bleak winds which usually prevail in the course of the very severe seasons of some hard winters; then, although the inhabitants are accustomed to the rigour of their climate, yet, because the natural effects of habit have their limits, the action of the excessive cold has the effect of benumbing the body and paralyzing the fibres of the heart and arteries; whence arises the sensible deterioration of the pulse, which from being strong, full, developed, and rare, such as it is when the cold is not beyond measure excessive, it becomes, on the contrary, weak, small, slow, and unequal, and always preserves its rarity; with the difference that the rarity of the pulse arises, in the second case, from the numbness which paralyzes the fibres of the heart, and from the slackening

the course of the blood which results from it. "*A frigore nempe,*" says Haller, "*sanguinis, ut cujuscunque alterius liquoris motus diminuitur.*"*

The baleful effects of excessive cold are increased both in number and strength, when the inhabitants of temperate and warm climates expose themselves to it; especially when they do so without previously familiarizing themselves with the natural severity of northern climates. The fatal disaster, which happened in Napoleon's army, with the loss of so many brave warriors of every age and rank, who perished in Russia, in 1812, from the effects of excessive cold, is a convincing proof of it.

Another striking proof of the influence of various climates upon the physical constitution, and upon the pulse, is clearly observable in the passage of the inhabitants of cold climates to southern countries, and *vice versa*. Thus, the pulse of the Russians, which is perfectly full, elevated, strong, and rare, in their own country, acquires on the one hand as many degrees of celerity in warm climates, as on the other, it loses of fulness and force.

* Haller, Op. et loc. cit. p. 265.

The action of the warm and burning atmosphere of southern climates must deteriorate the natural strength of the tissue of the organs of Russians, who, from having acquired the robustness of the body under the influence of a cold climate, which therefore becomes necessary to their preservation, must necessarily be weakened by the action of warm climates which is diametrically opposite to that of cold ones.

An effect contrary to that noticed in the inhabitants of cold climates is to be observed in those of southern regions; for, when these emigrate into cold climates, their pulse there acquires as many degrees of fulness and force, as it loses of celerity; and the improvement of their physical system increases with that of the pulse, in proportion as they have familiarized themselves with cold climates from their youth: only in case they arrive there at an advanced age, and suffering under chronic diseases, then indeed, in cold climates, the physical system and pulse of the inhabitants of warm climates grow worse, their weak and fragile constitution, being incapable of improvement, yields to the severity of the cold, it no longer being in the power of the old inhabitants of warm climates to renounce

the long habit of living under a warm atmosphere suitable to their physical wants.

The seasons, likewise, influence the state of the pulse in different ways. In general the pulse becomes elevated, full, and developed, in spring, its celerity being moderate. The temperature of the atmosphere, which in spring is neither too high nor too low, preserves the vital powers in a certain equilibrium, and the more this season advances, the excitement and their improvement proportionably increase. The human body passes from that state of numbness (in which it is generally found in the course of the winter), to that of moderate energy communicated to it by the stimulus of the atmosphere, already warmed by the solar rays, which reanimate all living nature in the spring, and by this means is elevated the sphere of activity of the system of circulation of the blood, and consequently the action of the pulse which follows its fate, and beats in fact with some degree of energy and celerity.

But the effects of the temperature of the atmosphere, elevated by the presence of the solar rays, do not stop here: its temperature always increasing in the summer, it necessarily follows that the beatings of the

pulse must be raised in proportion, and the energy and celerity of that organ successively increase in proportion as the season advances: as soon, however, as the temperature of the atmosphere becomes too elevated, as is the case in all climates in the period of summer, the stimulus of the atmospherical caloric upon the physical system of man becomes in like manner too powerful, and the pulse, which feels the effect of it, loses its energy and strength, and becomes weak, small, and unequal, although it preserves its celerity; the vital powers indirectly become languid, or by indirect weakness, the system of the circulation of the blood necessarily obeys this order of things, and hence arise the smallness and inequality of the beatings of the pulse which indicate the effect of the excessive atmospherical caloric, or of the high temperature of the air which prevails during the summer.

In autumn, the vital powers again resume their wonted force and energy, and by this means also the pulse recommences to beat with vivacity and strength: the stimulus of the caloric being in no wise excessive in autumn, and the temperature of the atmosphere being consequently moderate, there is nothing to prevent the regular exercise of the pheno-

menon of life, and the heart and arteries therefore indicate the regularity, energy and strength of the organic functions, by their equal and strong pulsations; such indeed are observed to be the beats of the pulse of adults in the autumnal season.

But the cold which comes on in winter does not fail to deaden the vital powers, by depriving them of a portion of animal caloric: for this reason the nervous powers become concentrated in the internal parts of the body; the heart and arteries perform their contractions and dilatations more slowly, and the pulse, which necessarily participates in the state of torpidity and languor of the organs, and of the concentration of the sensitive powers, must necessarily become languid, slow, small, close, and weak, such as it evidently shows itself during the prevalence of excessive cold.

The effects of the different climates and seasons have so sensible an effect upon man's physical constitution, that the inhabitants of the civilized world have felt the necessity of sheltering their bodies with clothing; and these different modes of dress have an influence upon the state of the pulse. In general, either the fashion of the clothes, and the quality of the stuffs whereof they are made, contribute

to increase more than is proper the temperature of the body, or they do not increase and preserve it in a degree equal to the want which man feels of defending himself from the disagreeable sensation of cold: in the first case, because the clothes increase in an excessive degree the animal heat, accelerate the course of the blood, and consequently the beats of the pulse; and in the second, because the body is not sufficiently defended from the severity of the cold, and comfortably excited by the caloric, and by the stimulus of the clothing in no way adequate to the necessity of the occasion, there results this inconvenience, that the exercise of the circulation of the blood becomes weak and slackened, and the pulse, which is dependent upon it, is found to be small, languid, slow, and weak.

The action of the viands, which arrive in the cavity of the stomach after the process of mastication, is likewise capable of altering the state of the pulse. Generally speaking, the action of the viands accelerates the beats of the pulse: thus also, in proportion as the viands are more highly seasoned with spices and other hurtful stimulants, the pulse becomes more accelerated. "*Cibus*," says Albert Haller, "*pulsuum numerum auget, etiam*

gustatio, sed prandium magis, etiam ad tres quatuorve horas. Augmentum 4. 5. pulsum reperit Johannes Floyer. Schwenke idem incrementum ad 8. et 14. æstimat." The same author also observes, "*Facile intelligitur, majus incrementum fore, si cibi copia major adsumpta fuerit.*" Haller adds in another part of his work, "*Cibus sumptus, chylum cordi submittit, pulsumque, non minima ratione, reddit frequentiore.*"*

So sensible, indeed, is the elevation and acceleration received by the pulse from the action of the viands, during digestion, that this increase of quickness of the pulse has by many physiologists been likened to a species of hypersthenic fever, so greatly, especially in certain individuals, are its beats or pulsations accelerated. Upon this fact is founded the reason for ascertaining, during the examination of the pulse, whether the patient has taken any medicinal or nutritive substance; since the presence of either of them in the cavity of the stomach materially changes the pulse from its natural state: hence, in order to determine with certainty, whether the alteration of the pulse belongs, in

* See Haller, *Op. et loc. cit.* p. 264 and 251.

such cases, to the action of the viands or medicines, or to the stimulus of the disease; we must endeavour to deduce from the quality of the food or medicine, and from the time which has elapsed since it was taken, if its dissolution or decomposition be, or not, effected, because with its decomposition the acceleration of the pulse also disappears; which gave occasion to the celebrated reformer of physiology to observe, “*Quando ciborum digestio absoluta est, quarta fere a prandio hora, pulsuum frequentia evanuit, et prior rediit tarditas.*”*

We may also here observe, that it is not always possible to affix the time employed by the stomach in the decomposition of different meats, or medicines. This time is relative to their quantity and quality, and more especially to the state of chemico-vital powers of the stomach: this knowledge also is not sufficient to determine it, since the effects of the peaceful or disturbed mind undoubtedly influence the quickness or slowness of the exercise of digestion. By recalling, however, to the memory, all that contributes to the phenomenon of digestion, we may rather determine whether

* Haller, Op. et loc. cit. p. 264.

the celerity of the pulse be the effect of digestion, or depends entirely upon the action of the disease. The fact is, that the sensation of heat experienced by man during the act of mastication, and the caloric that escapes from the decomposition of food in the successive progress of digestion, both act as new stimuli upon the physical system, and raise the sphere of its activity. What more permanently contributes to this effect is the physico-chemical action of the food upon the villous membrane of the stomach, and from the concurrence of these different actions there results a general change in the phenomenon of life: it may be said, that all the vital functions are then exercised with quickness and energy; the heart and arteries in fact contract with greater frequency, as is clear from the observation of the agitated pulse, and the whole concurs in accounting for the elevation of the sphere of activity of the exercise of life, which takes place in the course of digestion, in which the pulse beats with celerity, energy, and force.

In cases, however, of repletion, or excessive eating, an effect quite contrary to the first is observable in man; for, instead of witnessing the energy and elevation of the vital powers,

and consequently the celerity and strength of the beats of the pulse, which it obtains in the course of a regular digestion, we perceive, on the contrary, the depression of strength, an irresistible desire to sleep, or some other effect of the excessive fulness of the stomach, indicated by the languor, slowness, and irregularity of the pulse, arising from the reaction, or reflux of difficult and painful digestions which are the result of it.

Sometimes the mass of food, greedily introduced into their stomachs by gluttons, is so large, that the spasm of that organ is a necessary consequence, and corresponds to the excess and quality of food, and to the smallness, weakness, and slowness of the beats of the pulse. Bichat, however, maintains that the course of the blood is equally quick in the state of fulness as in that of vacuity or emptiness. “ Si sur les animaux
“ vivans,” observes he, “ on met à découvert
“ les organes creux, comme l'estomac, les
“ intestins, etc.; alternativement dans l'état
“ de plénitude et dans celui de vacuité, j'ai
“ remarqué que la circulation est presque
“ également rapide dans l'un et dans l'autre
“ cas, quoique cependant la plénitude rende
“ presque droits les vaisseaux de ces organes,

“ et que la vacuité, en les forçant à se replier, augmente leurs courbures.”*

In the first place, it is agreed upon by all the first physicians of Europe, that the circulation of the blood is quick at the time of digestion, and rather slow when the stomach is empty of food. Hence it appears clear that Bichat's experiment is in opposition to the results of daily practical observations. It should on the other hand be remarked, that Bichat has perhaps been deceived by his senses, in making the above experiment; since it is not known whether he had observed the course of the blood in the vessels of the stomach with the eye, or with the touch: if with the first, it may be objected that this sense is commonly too fallacious to be trusted to in a case of this nature; the more so, as we have already shown, that the beating of the arteries is not perceptible by the eye; the only method to be employed, when necessity requires, in order to ascertain the state of the circulation of the blood, is that of applying the fingers upon the arteries: if Bichat therefore has observed the course of the blood in the vessels of the stomach, or of the intestines, by

* Bichat, An. gén. Tom. ii. p. 268.

means of the touch, it should be considered that he might have performed his experiment whilst the stomach was too full of food, which leads to a false deduction; for, the excessive fulness of this organ, slackening the course of its circulation, is the cause that it is not materially different from what is observed in the vessels of the same stomach, void of food. But, in fact, the blood circulates rapidly in the vessels of the stomach, throughout the whole process of digestion, and slowly, or with rather less celerity before a meal. "*Jejunium*," says Haller, "*per eadem, pulsum minuit. Hinc continuo ante prandium pulsus tardior, et debilior, et frigoris facilius sensus: a pastu incalescimus*,"* which decision of Haller is evidently contrary to Bichat's experiment, which is even contradicted by what Bichat himself observes, when he says, "Voyez ce
 "qui nous arrive après le repas: ordinaire-
 "ment une légère augmentation du poulx,
 "effet du mélange des principes nutritifs avec
 "le sang, en est le résultat."†

Spirituuous liquors are still more expeditious than meats in accelerating the course of the

* Haller, *Ibid.* p. 264.

† Bichat, *An. gén.* Tom. i. p. lxi.

circulation of the blood, and consequently the beatings of the pulse which are dependent upon it. All wines hitherto known, the spirit of juniper, French brandy, Jamaica rum, and all the other liquors which luxury and civilization have unfortunately introduced, all act powerfully upon the palate, and upon the villous membrane of the stomach, whence the effects of their stimulating power are diffused over the whole nervous system, and consequently over the blood-vessels and the muscles. The mental alienation, artificial or factitious, which proceeds from the excessive use of wine or spirituous liquors, and the imperfect paralysis of all the muscles of the intoxicated person, are a convincing proof of it. Not one only, but frequent opportunities have presented themselves, of observing the pulse during the state of inebriation, in which it appears agitated, quick, strong, and impetuous; thus, the more advanced the state of intoxication, the greater is the disorder which prevails in its beatings; and from elevated, strong, and impetuous, such as the pulse is found to be at the commencement of intoxication, it becomes at last small and perceptibly irregular on account of the alteration, and depression of the sensitive powers, an alteration and depression

which precede the slowness of the circulation of the blood. In one case only the pulse continues energetic, developed, and strong, as is observed to be the case when a moderate use is made of spirituous liquours; whilst it is, as I have said, agitated, strong, and impetuous, in the commencement; and languid, small, and unequal, in the last period of intoxication. The variations of the pulse which result from the excessive use of spirituous liquors become more sensible to the touch, when the excess has been committed upon a fasting stomach, their stimulating power being in a direct ratio with the weakness of the body, and their effects more active in injuring its organization; for, when they do not extinguish life at one blow, they leave it a prey to incurable infirmities. The alterations of the vital powers, and of the pulse which take place in the commencement of intoxication, yield to emetics, to vegetable acids, to cold local baths of the external organs of generation, &c.; and those which obtain during its height, are overcome by the use of black tea, strengthened by a few drops of diluted sulphuric acid.

The abstaining from necessary food and spirituous liquors, when the habit of using these has been contracted in early life, depriving man

of the means of repairing the daily loss, and of restoring his strength, impaired by the use of life, produces an effect upon his economy altogether contrary to that which obtains by means of food and spirituous liquors; I mean the weakness of the organs, the decay of the vital powers, and consequently the slowness of the contractions and dilatations of the heart and arteries, which declares itself to the touch by means of the weakness, smallness, rarity and slowness of the pulse, exactly characterizing the state of abstinence from food and spirituous liquors: therefore due allowance should be made in the state of disease, in order to avoid attributing exclusively to the morbid cause, the fall of the pulse from its natural state.

ART. XII.

OF THE ACTION OF MEDICINES, OR AIDS OF ART,
UPON THE PULSE.

To the second section of external stimulants belong, as I have before said, the medicines, remedies, or aids of art. These, like food both solid and liquid, also influence the pulse in various ways. It is true, that the different remedies are administered during the state of diseases, so that it might appear, that their effects ought not to affect the physiological state of the pulse; but it is not less true also, that in order justly to appreciate the real value of its alterations, it is necessary to have always present to the mind the various effects produced upon the pulse by different remedies; since, in all cases of disease, we may be enabled to distinguish the changes and variations of the pulse which are the result of the action of medicines, from those which arise from the progress of every acute disorder: whilst by this means the variations of the pulse arising from two different causes are distinguished from each other, we have likewise the advantage of being able to trace with accuracy the progress of different dis-

cases, attributing the variations of the pulse, at one time to the stimulus of the remedies, at another to the action of the disease, and again to the concurrence of both, when such is the case. Now all these advantages which are obtained from a previous knowledge of different effects produced upon the pulse by various remedies; all concur in the important object of deducing from the improvement of the pulse the utility of various remedies administered in different diseases, and of foreseeing their event and termination.

Thus cinchona, in its quality of a tonic substance, strengthens the vital powers; increases the energy of the circulation of the blood, and in this way, accelerates, develops and improves the condition of the beats of the pulse. Those who make use of Peruvian bark, says Raulin, have an elevated and rather soft pulse, which shows the utility of this tonic substance in hyposthenic affections of the lungs, in which it is required to elevate the sphere of activity of this organ. In two cases, however, it happens that the use of cinchona deteriorates the condition of the pulse; the one is when the error of prescribing it in an immoderate dose has been committed, and the other when it is improperly administered in the access of fevers, or in hy-

persthenic disorders which apparently consist in the excessive tone of the vital powers. The great evil is, that whilst the pulse gets worse in consequence of the injudicious use of the above-mentioned bark, this deterioration is often attributed inadvertently to the obstinacy of the disorder; an error which necessarily gives rise to the most serious consequences. In cases like these, the deterioration of the pulse appears from the smallness, weakness, and celerity of its beats, and results, as I have said, from the improper administration of this powerful medicine.

The elevation or smallness of the beats of the pulse, which may arise from the use of cinchona, is therefore another proof which shows whether this has or has not been well indicated and properly administered. In the first case, the pulse acquires new degrees of strength, flexibility and energy, and beats more regularly; and in the second, it becomes concentrated, small, weak, and beats irregularly, which shows the necessity of suspending the use of it. We have derived no small degree of satisfaction from having, in certain cases of malignant fevers, caused the use of bark to be suspended, less because it had been administered without the patients having been

previously prepared to support its activity and power, than because the pulse, instead of developing, raising, and showing itself rather soft, as is the case when bark is properly administered, was observed to be rather small, weak, quick, and unequal; that is to say, deteriorated in such a manner as not to excite our astonishment at the effect produced by an irregular use of this valuable medicine.

The effects produced upon the pulse by camphor vary according to the dose given. Camphor when administered in small quantities, animates the vital powers, weakened by long-continued chronic diseases, and by the baleful effects of nervous and malignant fevers. By the help of the tonic action of camphor, the sphere of activity of the internal organs is elevated; the circulation of the blood takes a certain tone of energy, and the pulse consequently becomes improved; since its beats appear to the touch developed, elevated, and energetic, in consequence of the use of camphor, as is ascertained by observation: with another peculiarity, well worthy of being noticed; viz., that when the pulse is too quick, from the effect of extreme weakness, the use of camphor moderates its celerity; and, on the contrary,

increases it, when the pulse is too slow, on account of general debility or asthenia. Both the slowness and quickness of the pulse are the effect, in this case, of depression of the vital powers, although the one variation appears different from the other: but camphor, which increases the energy of the vital powers, must necessarily accelerate the pulse when it is too slow, and retard the course of its beats when they succeed each other with too much quickness.

In one case only camphor invariably slackens the course of the blood, and the beatings of the pulse: this is when it is administered in strong doses. Such, at least, is the result of practical observations which have excited the attention of several eminent physicians. But, notwithstanding this, the direct action of camphor upon the human body has hitherto remained involved in complete obscurity. It is only by dint of perseverance in researches of this kind, by studying the nature and effects of this resin at the bed-side of the patient; it is only thus, that the mind can be enlightened as to its nature, since the few facts hitherto afforded us by observation, will not yet allow us to generalize upon the mode in which it acts on the living system.

Opium diffuses the effect of its stimulating virtue from the cavity of the ventricle, where it first exercises its action, over the nervous system, and over that of the circulation of the blood, enlarging the sphere of its activity, and accelerating, with that, the beatings of the pulse. The idea formerly entertained by physicians, that opium weakens the nervous power, and slackens the course of the blood and the beatings of the pulse, arose from the error of confounding, as many authors have done, the effects of the abuse with those of the moderate use of opium. “*Hæc hoc loco non refello,*” says a learned author, “*qui norim usum modicum opii pulsum frequentiam augere. Utique minuere dederim, quando cordis vires vehementius fregit.*”*

Thus, it is not the nature, or chemical character of opium, which causes the weakening of the vital powers, but rather the immoderate doses in which it is given, or its abuse, that throws the system into a state of depression. In this way all known tonic medicines may doubtless weaken in a similar manner. Now, the effects which arise from the action of

* See Mém. sur les parties sens. Tom. iv. Réponse à M. Whytt.

tonic remedies are relative to their chemical character, and to their doses, but especially to the physical dispositions of the various individuals to whom they are administered. The habit, however, which is gradually acquired by the constant use of tonics, may alter their strength, and weaken their activity. An instance of this is observable in the Turks, who, being accustomed to masticate opium from their tender age, can, when attacked by disease, employ large doses of it, without the least ill consequence; thus the use of opium is frequently of no utility to them, so much are they familiarized with it when in health. At all events, we constantly observe in practice an acceleration of the beatings of the pulse by means of the moderate use of opium, which increases the sphere of activity of the sensitive powers, and of the vascular sanguineous system. The inebriation or ecstasy which generally results from the use of opium, is another reason to confirm us in our opinion that it acts by excitement, and thus accelerates the course of the blood, and the beatings of the pulse.

The continued use of mercury also accelerates the beatings of the pulse, and at the same time causes it to be rather hard,

and more or less strong, especially when administered to persons of a robust constitution. On the appearance of salivation, when this excretion takes place, the pulse then appears agitated, irritated and small: and, upon the copious ejection of saliva increasing, it becomes proportionably more agitated, smaller and thinner, especially in persons who are weak and of a sickly constitution, in whom the prostration of vital powers which results from the great loss of this recrementitious juice becomes more sensible. But, when the mercury does not excite orgasm in the glands of the throat, nor produce the salivation which is the effect of it, it causes two different changes in the pulse; either the pulse is slow and rare, as we generally observe in persons affected with obstructions in consequence of syphilis badly treated; or it is very quick, such as is seen in lymphatic fevers; in the first case, the pulse loses its slowness, and in the second its excessive quickness, always in consequence of the beneficial effects of mercurial preparations; since both variations of the pulse; viz. the slowness and excessive quickness, are produced, in the two supposed cases, from the state of general languor, to which may be added the state of affection

of the lymphatic and glandular systems ; and the action of mercury which increases the tone of the vital powers, and replaces in their former equilibrium the organs affected, at the commencement, with syphilitic lues, either destroys or neutralizes the venereal poison, and by this means accelerates the pulse when it is too slow, and moderates its celerity when this is excessive ; since both, as I have said, the slowness and quickness derive their origin from the same cause, which the chemical action of mercury overcomes and destroys.

Purgatives at one time elevate and accelerate the beatings of the pulse, and at another, weaken and retard their course : they elevate and accelerate them in complicated cases of overloading of the viscera ; but they weaken and retard their course, when abused by being administered in large doses, or at improper times. The elevation and acceleration of the pulse, in complicated cases of overloaded viscera, arise from the effect of purgatives which in removing the localities, the overloadings or embarrassments of the viscera, remove also those obstacles which have a tendency to oppress the body, and at the same time, prevent, as is well known, the free circulation of the

blood, which, while these visceral obstructions exist, cannot distribute itself uniformly over the whole arterial and venous systems; a distribution upon which depend the freedom and energy of the beatings of the pulse. But the pulse loses its natural strength, and becomes small, deep, weak, and rather slow, when, together with the exhaustion of the organs of their proper nutritive juices, we perceive the state of atony in consequence of the abuse, or ill-judged administration of purgatives, which is unfortunately but too frequently observed in practice; for, the mania of wishing to cure every disorder by means of repeated purgatives, is now more than ever in great repute among the most civilized people of Europe. To this has contributed, in no small degree, the method of M. Leroy, and of many others, who, with their sometimes serviceable purgatives, have drawn upon themselves the attention of the most numerous class of society, by boasting their efficacy in every illness.

The variations which diaphoretic, expectorant, and diuretic remedies produce upon the pulse may be reduced to three: when these remedies by means of their action, set at liberty the course of the circulation of the

blood from local obstructions, or accumulations of white humours, which may take place in the cutaneous system, in the lungs or in any other part of the body; they render the beatings of the pulse more free, energetic and quick, in consequence of the beneficial excretions produced by them. Thus the pulse becomes somewhat soft, elevated and active, as we shall have occasion to observe, when we come to treat of critical pulses. The favourable character which the pulse acquires by means of the use of diaphoretics, expectorants and diuretics, is such, that it can announce, as we shall see, the approach of sweats, mucous expectorations, or copious flux of urine: and when, on the contrary, the pulse is hard, vehement, and too quick, such as is observed in phlegmasiæ, inflammatory fevers, and other hypersthenic diseases, it ceases to be so by means of diaphoretic, expectorant and diuretic remedies, and becomes regularly quick, elevated, and somewhat soft; sometimes their effects are critical, since they assist nature in removing the obstructions or congestions which may exist in the above mentioned parts. By this means the mass of the blood distributes itself uniformly through the arterial and venous sys-

tems; whence result the regularity, freedom, and natural strength of the pulse. The other variation of the pulse is dependent upon the injudicious administration of the above remedies, which, when not well indicated, or properly administered, promote, in an excessive degree, perspiration, expectoration, or copious ejection of urine; and these excretions not well indicated at that time diminish irregularly the mass of humours, relax improperly the chord of excitement, depress the whole system, lessen and weaken, and consequently render slow, rare, and weak, or small the beatings of the pulse. Thus it happens, that from the state of the pulse we may judge of the utility, or of the bad effects of different remedies which are daily employed in the treatment of various diseases to which the human body is subject.

In like manner the beatings of the pulse vary according to the temperature of the water employed in the form of a bath. The pulse becomes slow, small, thin, and deep, in the cold bath; it appears quick and small in the tepid, and strong, quick, and elevated in the warm bath: but when the perspiration of the whole surface of the body, increases

more or less by means of a bath perceptibly warm, then the pulse becomes gradually smaller, and successively languid, weak, and unequal. The equilibrium and energy of the vital powers exceeding, as it happens, the natural limits, by continuing the stimulus of the high and elevated temperature of the perfectly-warm water of the bath, cease to exist there, and the pulse immediately appears to be deteriorated, announcing by this circumstance the prostration of the vital powers, of which we have an example in the night-sweats of consumptive people. More immediate than the effects of the warm bath, are those of vapour baths and stoves, the action of which succeeds in less time to produce in the human machine, by means of profuse sweats, the depression of the vital powers, especially when the rule is not observed of proportioning the duration of vapour baths and stoves to the sex and age of the patient, to the character of the disease, and, above all, to the actual state of the individual's strength, to whom similar means of art are about to be applied. In the first moments of the action of vapour baths and stoves, the pulse is raised and developed, and becomes accelerated to a certain degree, be-

yond which the pulse again changes, and becomes small, unequal, and not seldom intermittent.

Poisons of every class, which produce even in the smallest dose an extraordinary stimulating power, a power which distinguishes them from other substances of a regular and limited activity; the poisons, I repeat, increase in an excessive degree the intensity and vehemence of every internal movement of the body; raise more and more the exercise of the circulation of the blood, and sensibly accelerate the beatings of the pulse. The exaltation of all the organic functions advances with such rapidity, through the continuation of the stimulus of the poisons, that it at last becomes confounded with the extinction of the vital powers; and the person poisoned may pass, in more or less time, from that state of excitement, irritation and violence, to the total exhaustion of his strength, and thus ends his life amid the most excruciating agonies. The pulse, in the transition above mentioned always follows the state of circulation of the blood, the exercise of which is raised and elevated up to a certain degree, and the pulse appears in like manner quick, agitated, violent, hard, and vehement, such as is observed

in the contest between the action of poisons and the reaction of vitality: hence the course of the circulation of the blood becomes slow and languid, and the pulse suddenly appears small, weak, slow, thin, deep, irregular, and finally intermittent: so that from the state of the pulse it may be easily seen whether or not it be possible to rescue the person poisoned from death: in like manner, the greater or less activity of the poison may be deduced from the more or less rapid changes of the pulse, and consequently, to a certain extent, its species.

To the general character of the remedies hitherto mentioned, which is that of exciting, irritating, and increasing by excitement, the course of the circulation of the blood, and the beatings of the pulse; to this general character is diametrically opposed the mode of action of tartar emetic, laurel-water, aconitum, and especially that of digitalis purpurea, and other similar substances. The use of tartar emetic diminishes the frequency and celerity of the pulse, a remark for which we are indebted to the observation of the profound Dr. Rasori, who, on account of this property of tartar emetic, calls it a *counterstimulus*; that is, a substance which opposes irritation, and stifles, so to speak, the inflam-

matory state. A similar kind of action he attributes to various other substances, which he has successfully employed in various inflammations.

There can certainly be no doubt upon the subtraction of the celerity and frequency of the pulse by means of tartar emetic; the doubt is rather upon the opinion, whether the diminution of the celerity and frequency of the pulse is directly produced from the chemical character of the mineral emetic, or rather from the nausea and the weak attempts at vomiting, which it excites and produces in the stomach. It is probable that the antiperistaltic motion of the intestinal tube contributes to attract the partial forces of the body to the centre of the irritation; that is, to the ventricle, where the tartar emetic acts immediately: it appears then that the subtraction of the celerity and frequency of the pulse should be derived from nausea, and the slight attempts at vomiting, and not from the direct action of the emetic. In fact, if the patient be allowed ever so little rest, without being sensibly disturbed by nausea and vomiting, the pulse then as if it would profit by this opportunity recovers itself a little, and appears rather quick, and then again

becomes slow upon the approach of nausea and vomiting.

Doctor Double, speaking in fact of the subtraction of the celerity and frequency of the pulse, which also arises from the use of *digitalis purpurea*, observes that this plant excites nausea and vomiting, and by this means, he says, slackens the course of the beatings of the pulse. The same writer adds, that when the use of *digitalis* has been continued for a certain time, the pulse then assumes the character of an irregular pulse, which announces the necessity of suspending it. The incertitude in which we are as to the true manner in which counter-stimulants act, does not allow us at present to decide, whether tartar emetic, *digitalis*, and all the other counter-stimulant substances of Dr. Rasori have the chemical property of slackening directly or indirectly, by their effects, the course of the circulation of the blood, and the beatings of the pulse. Here, however, it suffices to know, that the above-mentioned substances sensibly moderate the excessive quickness and frequency of the pulse.

Bleeding, cupping, and leeches, also cause variations in the pulse. It is generally known by all physiologists, that the blood and se-

condary humours, while they perform the office of stimulants, and excite without interruption the vitality of different organs; keep up their strength and energy, and thus prolong the course of the phenomena of life, which receives, by means of the arteries, the elements of its preservation. That the humoral mass is indeed the immediate support of the solids and of the exercise of life, is a truth deduced as well from the fact of the artificial death of animals, whose veins have been opened, as from the observation of the quick and profound depression of the vital powers in consequence of an excessive flux of the rectum, or copious bleeding, to which most frequently succeeds the asphyxia, so much does the sensible diminution of the sanguineous mass suddenly weaken the exercise of vital functions, and the contractions of the heart.

Hence, bleeding, which causes a subtraction of blood, must and does exercise an immediate influence upon the circulation of the blood, and consequently upon the beatings of the pulse. Physicians who know the importance of this fact, have therefore recourse to bleeding, as often as it is desired to moderate the violence of the course of the blood, and the vehemence and celerity of the pulse; phenomena which

take place in obstinate phlegmasiæ, in inflammatory fevers, and other similar diseases: when, by bleeding, we diminish the sanguineous mass, we succeed in lessening the impetus of the course of this fluid, in slackening the too tense chord of excitement, and in keeping within just limits the over-exalted exercise of the organic functions; and thus, by means of bleeding, is obtained the advantage of moderating the excessive quickness of the pulse. But, when the inflammations are violent, and the patient's blood is too dense and thick, then bleeding, on the contrary, develops and accelerates the pulse. The sanguineous waves are then so crowded together in the blood-vessels on account of the plethora which predominates in such disorders of excessive vigour, that the course of the blood, or its circulation, is with difficulty performed; the more so as the arterial vessels, which find themselves clogged up, as it were, obstructed with blood, cannot freely perform their systoles and diastoles; for this reason, their beatings must necessarily be weak, obscure, and deep to the touch; and the bleeding, which lessens the mass of the blood, and removes the obstruction from the blood-vessels, renders the circulation more free, and thus

develops and accelerates the beatings of the pulse. The other effect of bleeding upon the pulse may be that of too much lessening and weakening its beatings: this happens, when the practitioner, without forming to himself a correct notion of the mode in which bleeding acts, prescribes it in cases, where it is not well indicated, and the deterioration of the pulse always follows as a consequence of this error.

The application of cupping-glasses and leeches upon inflamed or diseased parts, produces similar effects upon the pulse: whilst these external remedies disengage the blood-vessels belonging to the parts affected, from their excessive and forced dilatation, they relieve them, at the same time, from the irritation, conformably with the object of the indication; and by this means they succeed in lessening the frequency, vivacity, and hardness of the pulse, which indicate and attend local hypersthenic inflammations. And when the pulse is small, deep, obscure and oppressed, such as it is observed in chronical inflammations, or hyposthenic congestions, where the blood becomes accumulated, and obstructs the vessels; leeches and cupping-glasses, which relieve the parts so affected, by disengaging

the capillaries of their obstructions, develop, and for the moment render more free, the beatings of the pulse: I say, for the moment; because weakness is, in substance, the root of every chronical congestion; and, therefore, the cure of chronical affections, or hyposthenic inflammations and congestions, by means of cupping-glasses or leeches, cannot but be momentary; and it is precisely this reason which exposes the patients to a relapse.

The effect produced upon the pulse by clysters, is relative to the nature of the complaint in which they are employed. The pulse becomes elevated and developed from the effects of clysters on the overloadings of the viscera of the lower belly, during which the pulse becomes more or less deep, small, hard and irregular. On the contrary, clysters lessen, slacken and weaken the beatings of the pulse, when they are abused, or employed without the least necessity, in hyposthenical diseases, especially in the case of weak and delicate women.

The sinapisms, usually applied to the soles of the feet, or upon any other external part of the body, have also an influence upon the variations of the pulse. When the pulse is small, deep and hard, as is generally observed in gouty spasms of the breast, or of the viscera of the lower

belly, the action of sinapisms frees it from its oppression and smallness, and causes its beatings to become yielding and elevated. The reason of this variation of the pulse is found in the power which the sinapisms possess, of drawing the humours from the parts affected, or from the centre of the irritation to the extremities of the body, where they act in this manner. By this means the sinapisms concur in distributing uniformly, by their action, the mass of the humours through the whole extent of the system of the blood-vessels, and thus disengage the capillaries of the parts affected of that which is the cause of the pain, spasm, or affection; whence arises the improvement of the pulse, which, from being irritated, small, thin, deep, and quick, becomes free, developed, soft, and moderately quick, in consequence of the beneficial effects of the application of the sinapisms.

Blisters, by their chemical action, have a still greater effect upon the pulse than the sinapisms. Scarcely do the blisters begin to alter the tissue of the common integuments, when the exercise of the circulation of the blood becomes elevated, and the pulse is then hard, rigid, tense, and quick, as if nature were desirous of shewing the uneasiness which the

nerves of the affected part suffer, in the presence of the irritation occasioned by the stimulus of the blister: to the hardness and tension of the pulse is added a species of febrile agitation, which is in fact observed during the action of the blister, especially in persons more liable to excitement, and of a delicate constitution. Afterwards, upon the termination of the process of suppuration, which is effected with the progress of the inflammation of the part, the pulse immediately passes from the state of rigidity and febrile agitation to that of its natural softness, agility, and regular manner of beating.

CONCLUSION.

SETTING off, therefore, from the knowledge which we have acquired respecting the variations of the natural pulse, whose beatings or rhythms are in an adult, more or less uniform, flexible, vigorous, and moderately quick, in the state of health or equilibrium: or, in other words, setting off from the positive and general ideas which constitute the object of the physiological state of the pulse; it will neither be a difficult nor a laborious task to show the line of demarcation which divides the natural from the morbid pulses of every kind and species. But, in order to avoid the uncertainty of things in so important a subject as that of deciding without hesitation whether the pulse of this or that individual be natural or morbid; it is of material consequence to recall to the mind, in every investigation, not merely the natural variations of the pulse; which are distinctly observed in the various periods of life, in both sexes, in the different bulks of the body, and in the various statures and complexions; but also the changes which arise from the play of the passions, from the

influence of the intellectual faculties, from the particular mode of living, from the action of different climates, and lastly, from the effects produced upon the excitability by various remedies or aids of art.

In fact, all the natural variations of the pulse, and all its natural changes, which are produced by the action of stimuli, both internal and external, all are a representation, a type or model, given by science, in order to proceed regularly to the examination of the pathological state of the pulse, and from which is derived the reason for believing this or that pulse to be natural or morbid in the various periods of life. We therefore conceive that we cannot sufficiently recommend the study of, and an intimate and thorough acquaintance with the physiological state of the pulse, since it requires all the sagacity and experience of a person perfect in the art, not to confound, in various cases of concealed diseases, and of mental affections, the morbid with the natural pulses and *vice versa*. As a proof of this, it will suffice to add that examples in practice are not rare of seeing persons who have an irregular or intermittent pulse, although enjoying perfect health. Thus also, what is more important to be known is, that

from being irregular or intermittent, as the pulse is frequently observed in the healthy state, it becomes regular in the morbid one. Many cases of this description have attracted our attention. One among others which I shall notice at present is that of a Neapolitan person of rank, who had the left-hand pulse naturally intermittent, and its intermittence ceased to exist in every febrile disorder with which he might be attacked. De Haën himself, who was a man of considerable experience in medicine, relates several cases of pulses naturally irregular, which became quite regular in the morbid state, and whose irregularity reappeared immediately upon the termination of the disease, and consequently upon the re-establishment of the patients to the state of health.

Wolfgang and John Khern have likewise observed the pulse naturally intermittent in some individuals in the healthy state. See Ephem. Academ. natur. Curios. "*Pulsus naturaliter intermittens.*" Berryat in like manner mentions the observation which he made upon a female, whose heart and arteries oscillated so obscurely, that it was difficult to feel the beating, although no apparent disorder could be alleged as the cause. Several other cases

of irregular or anomalous pulses, which have existed in a state of health, may be found in the work of the celebrated Morgagni: "*De sedibus et causis morborum per anatomem indagatis*;" in the work of James Nihell, entitled: "New and extraordinary observations concerning the prediction of various crises by the means of the pulse;" in the institution of practical medicine of Burserius; in the work of the worthy Corvisart: "*Essai sur les maladies et les lésions organiques du cœur*," in the epitome of J. P. Frank, and in various other classical works, both of ancient and modern date. "On peut trouver des personnes qui se portent bien," says Bordeu upon this subject, "et dont le pouls paroît fort mauvais en soi; et il y a des malades prêts à entrer dans l'agonie, dans lesquels le pouls paroît bon en soi."*

From these practical observations we derive two luminous rules; the first is, not to be alarmed as soon as we perceive either irregularity of the pulse in certain subjects, who are slightly indisposed, because it may be, as not seldom happens, that they have the pulse naturally irregular, and that the slightness of

* Bordeu, Op. cit. p. 265.

their indisposition has not power sufficient to make it regular, according to the observation of De Haën, who asserts, as we have remarked above, that he has observed the pulse naturally irregular, which became regular in the morbose state. The second rule is, to foresee the imminent danger which threatens patients when they are seriously ill, and still have a regular pulse; the regularity of the pulse being, under such circumstances, worse than the irregularity itself: the presence of any irregularity of the pulse indicates at least the greater or less intensity of the disease, places the medical attendant on his guard, who naturally feels it incumbent upon him to search for the cause of the irregularity, and deduces also from its character, what may still be the remaining resources of nature, and what ought to be the means employed to second her salutary efforts, or to proceed with activity and care in the true plan of cure: now all these advantages are entirely lost, in the case of severe diseases, accompanied by the regularity of the pulse, because this, while it will not unveil the character and severity of them, and unfold the dispositions of nature, does not even allow the physician to act with the celerity required, and the diseases necessarily triumph. To the

unfortunate termination of severe disorders followed by the regularity of the pulse; Hippocrates was frequently an eye-witness: he affirms that he saw great numbers perish of malignant fevers, whilst their pulse was perfectly regular. Galen likewise makes mention of the obstinacy of severe disorders accompanied by the regularity of the pulse; he also witnessed the fatal termination of the epidemic fevers which in a similar manner deprived of life a prodigious number of patients while their pulse was regular. Not proceeding from this knowledge to the examination of the pathological state of the pulse, is equivalent to opposing the progress of the science, by depreciating all that has relation with the natural state of the pulse, which leads to a more intimate acquaintance with its physiological state.

The other case in which the pulse belies the natural appearance, and which may sometimes embarrass the mind of the physician; is that of dying persons. Whilst these are in the agony, their pulse undergoes a thousand changes; the most striking, however, among its numerous variations, is that of seeing the pulse become suddenly natural, from being small, unequal, and vermicular. And is it

not the certainty which at first occupies the mind, that such a change in the pulse of dying persons is caused by the last efforts made by nature in order to prolong life; is it not this certitude, previously acquired, which prevents the other error of retracting from the first opinion of death to which the patient is condemned, when even the pulse continues to show itself for a longer time under the aspect of a natural pulse? Of the greatest importance, therefore, is the information acquired by a close and deep examination which is necessary to be made *a priori* of all the natural variations of the pulse, and of all its irregularities, intermittencies, metamorphoses, and sudden changes, which take place in a state of health, and which are only momentarily in the morbid state, as is the case with the changes of the pulse in dying persons.

Without the previous knowledge that the pulse of women is naturally frequent and unequal during the first months of pregnancy, who would not, in the morbid state, attribute the cause to the severity of the disorder? The observation of the frequent and unequal pulse, in fact takes place in the first months of pregnancy: a phenomenon caused by the suspension of the menstrua, which generally

takes place, and which alters, in a certain degree, the course of the circulation of the blood, and the natural mode of existence of the nervous system of women recently pregnant. This double alteration is in fact announced by palpitations, fainting fits, internal convulsions, and by the frequency and inequality of the pulse; phenomena which in fact usually afflict women in the first months of pregnancy. The cause of these phenomena is the frequent sanguineous congestions, which are formed in the ventricles of the heart, in consequence of the suspension of the monthly courses. Compelled as the heart then is to disembarass itself of the superabundance of blood which obstructs and disturbs it, it redoubles its efforts, and consequently its contractions, whence arise, at the commencement of pregnancy, the vivacity, quickness, elevation, and agitation of the pulse.

To this state of forced activity of the ventricles of the heart succeeds the depression of their strength, which no longer permits them to contract and dilate themselves freely and regularly, and to drive forward, at every systole, the same quantity of blood, and hence, in truth, arise the irregularity and frequency of the pulse which characterize the second period of

pregnancy. At the end of the third month, the time in which the vital wants of the fœtus are continually increasing, the latter developing itself at the mother's expense; the sanguineous congestion decreases in proportion, and thus the frequency and irregularity of the pulse continue to decrease in the fourth month of pregnancy: we shall trace the other changes of the uterine pulse, from this period forward, when we come to treat of organic pulses. Now how fallacious would be the rule, of judging the acute disorders of pregnant females always fatal, because their pulse is frequent and unequal, or otherwise?

Thus, it has been clearly proved, that, in order not to confound, in all the physical circumstances of man, natural with morbid, or morbid with natural pulses, it is of the last importance to learn previously, or *a priori*, the natural state of the pulse in all the variations and modifications that it can and does exhibit in the healthy state. It is only this method of proceeding from the positive to the negative, and from the known to the unknown, that can conduct to the true end of science. Seeing, for instance, that there does not exist in the human body any physical cause whatever, which can naturally induce a variation in

the pulse, and that whilst there exists no reason why the pulse should be great or small, strong or weak, hard or soft, quick or slow, frequent or rare, &c., it is so : in such a case, should we draw the conclusion that this or that pulse is then morbid. In other words, if the pulse be observed small or weak in an adult ; slow or hard in a young man ; vehement and hard in a woman ; slow and rare in a child ; quick and soft in an old man, and so on in similar cases : if the pulse thus exhibits itself, whilst it should not do so in a healthy state, who could then any longer doubt of its being unnatural ?

But admitting that the pulse is, as it should be, small and frequent in a child ; great and full in an adult ; strong and developed in an inhabitant of the country ; lively, quick, and energetic in a woman ; rare and hard in an old man, &c. ; under such a supposition, is it not natural to foresee, that its smallness and frequency may be also excessive in a child ; its greatness and fulness in an adult ; its strength and vehemence in a countryman ; its quickness and energy in a woman ; its rarity and hardness in an old man, and that these variations of the pulse not confining themselves within the limits assigned by nature are not an

obvious consequence that the pulse should then be morbid?

In short, all the difficulty of verifying the presence of morbose pulses consists in ascertaining, at the moment of examining the artery, whether the beating of the pulse is such as it should be during the state of health of this or that individual; which is easily ascertained by comparing in the mind the beating of the pulse which is under observation, with its physiological state; for the analogy or the difference will show, either that it is in its natural state, or has suffered some alteration from it.

There still, however, remain other difficulties to conquer in the science of the pulse. First, it must be observed that every individual has a pulse peculiar to himself, differing from that of every other individual. Who could trace, then, all the natural pulses, with their variations, throughout the wide domain of animated nature, or in all the individuals composing the human race? Now, not knowing, *a priori*, all the variations of the natural pulse, how is it ever possible to make the comparison, in order to deduce from it its unnatural state, or alteration from its natural one? Finally, if the anomalies which usually exist in the natural pulse of certain individuals disappear in the

morbid state, as has been observed above, what physician could be sagacious enough to deduce, or even conjecture them, from its regularity, at the patient's bed-side ?

All these difficulties might be overcome, by introducing a general custom, if not among all, at least among the most respectable families of every nation, of having an able physician appointed to superintend the care of their health. Whilst such a person would be intent upon preventing the developement of the various diseases by the intelligence of Hygiene, which is the mathematical branch of medicine ; at the same time, he would not lose sight of the opportunity of becoming acquainted with the real character of the natural pulse of every individual belonging to the various families under his care ; to this he would likewise add the useful knowledge of the temperament, habits, and different modes of living, all which he would insensibly acquire in the course of his friendly visits. This idea is borne out by the opinion delivered by the learned Celsus, when he says : “ *Ideo-que, quum par scientia sit, utiliore tamen medicum esse amicum, quam extraneum.*”*

* Cels., Op. omn. Lib. iii. c. vi. p. 345.

In fact, if the case should ever occur, which may happen, and which often does happen in nature, that the pulse of this or that individual is naturally irregular or intermittent, and becomes regular in a state of disease; the physician will no longer be deceived by its malignity, concealed under the false appearance of the regularity of the pulse; he will no longer remain inactive, with his arms by his side, awaiting the coming on of the crisis, when it is necessary to attack it as soon as possible by the most efficacious means of art; nor will the difficulty any longer obtain, of knowing *a priori* all the variations and modifications of the natural pulse of every individual of the human race. “ Dans les maladies,” sagaciously observes the learned Fouquet, “ c’est un grand “ avantage pour le médecin que de bien connaître le pouls naturel de la personne qu’on “ traite.”* “ It is also necessary,” adds Baillou, “ to know what the pulse is during a state of health, otherwise the inconvenience will not fail to arise, of committing errors by proceeding without this knowledge to the treatment of diseases.” The task, therefore, was indispensable which we have undertaken, of

* Fouquet, Op. cit. p. 59.

examining the physiological state of the pulse, explaining all the variations and modifications together with the anomalies or irregularities which are peculiar to it in certain individuals, before proceeding to the examination of the morbid pulses, that is, those which accompany general diseases of every class, kind and species; those which result from organic affections, and those which announce the approach of the different crises.

ART. XIII.

OF THE RELATIONS THAT UNITE THE CIRCULATION
OF THE BLOOD WITH ALL THE OTHER FUNCTIONS
OF LIFE, AND WHICH ARE THE PROP, SUPPORT,
AND BASIS OF SPHYGMICAL SCIENCE, IN-
ASMUCH AS THEY EXPLAIN THE DIF-
FERENT MORBOSE PULSES.

IMPORTANT as it may be to determine the springs of the material instrument of the pulse, the mechanism of its exercise, and the natural variations, under which the pulse exhibits itself in a state of heath; it is not less so to examine the relations which unite the circulation of the blood with all the other functions of life; for, whilst they, on the one hand, perform the prodigy of uniting in one whole, the partial lives of the different organs belonging to man, they, on the other, establish the basis upon which is fixed the science of the pulse; since the harmony or discord of the above-mentioned relations is, as we shall see, the cause of the *natural* or of the various *morbose* pulses.

The first relations which present themselves to our examination, are those which preserve in a reciprocal dependence the circulation of the blood and the respiration. The blood,

which passes from the last ramifications of the aorta to those of the *venæ cavæ*, after it has completed its course through the different parts of the body, is black, thick, and altogether vitiated, so to speak, by the excess of carbon and of hydrogen, as well as frequently by the presence of many other foreign elements, which are there introduced through the thoracic duct, which pours them with the chyle into the left subclavian vein.* Thus

* From the combination of the chyle with the black-coloured blood, which operation takes place in the left subclavian vein, arises the real cause which no longer permits us to reject all the humoral diseases without any exception: in fact, in addition to the black-coloured blood being incapable of completely correcting itself, by reason of various circumstances, there may likewise concur the alteration of the sensibility of the chyliferous vessels and of the glands; and when (which is not seldom the case in practice) their sensibility is altered, the double inconvenience arises, that the chyliferous vessels absorb what they reject in the natural state, and that the glands then secrete humours very different from those which they produce in their healthy condition: now by these means many hurtful substances penetrate into the system of the circulation of the black-coloured blood, and thence pass into the system of the circulation of the red blood, which con-

heterogeneous, the blood cannot obey the pressing demands of life, a flame which would certainly be extinguished at the first gust of wind, were it not promptly succoured by the oxygen and caloric, and the other nutritive fluids, with which the blood loads itself in passing through the lungs.

For this purpose the cavity of the thorax is dilated by means of the intercostal muscles and the diaphragm; a column of atmospheric air then descends; the lungs exercise the act of inspiration, and the capillary vessels, which contain the blood, place it in contact with the inspired air, they being the nearest to the

veys them, together with this fluid, into the tissue of the different organs, which gradually receive a morbose impression: of this we have an example, in the deterioration of the organs of consumptive, scorbutic, and scrophulous persons. Besides, it cannot be denied that the intestines, the lungs, and the skin, are three apertures which are always open, in order to give free entrance to foreign particles, miasmata and atoms, which penetrate, as we have seen, into the circulation of the red blood, whence the different organs receive the germs of their state of indisposition, if not of various diseases which there develop themselves, and the cause of which is found in the alteration of the humoral mass.

reservoirs or air-cells; thence, almost instantaneously, by a concurrence of chemico-vital circumstances, is produced the change of the blood, submitted to the process of respiration, and thus also the black-coloured blood is enabled to appropriate to itself the oxygen and the caloric, which form part of the atmospheric air, and to which the blood is indebted for its red colour, and the elevation of its temperature.

That the blood does, in fact, appropriate to itself a portion of the oxygen and caloric of the atmospheric air at every inspiration, is proved by the physical experiment, which may be repeated at pleasure, of keeping a living animal under a glass-bell, till it dies, which is in consequence of the air contained therein not being renewed; for, upon examining the air which remains in the bell, after the animal's death, it will be found that the air therein confined has lost all its oxygen, while it possesses, in its stead, a corresponding quantity of carbonic acid, and of animal serum, substances which the air in the bell did not contain before the experiment; a circumstance which evidently proves that the blood loads itself with oxygen and caloric in the act of inspiration, and relieves itself from

the superfluous carbonic acid and animal serum in that of expiration.

After the physical certainty acquired by the above-mentioned experiment, it would certainly be vain to pretend, as some modern writers do, that the blood does not receive oxygen, but only caloric, in the act of inspiration, as if there was no weight in the other experiments which lead us to attribute the colouring of the arterial blood to the presence of oxygen.

Instead of throwing doubts upon the information which the science of chemistry has diffused over this fact, how much more important would it not be to determine, by the assistance of new investigations, whether the blood does, in fact, communicate to the expired air any portion of azote, together with carbonic acid and animal serum, or whether the inspired air is that which communicates it to the blood, together with oxygen and caloric; all three being components of the atmospheric air.

At all events, there is no longer any doubt that the function of respiration is that which modifies and perfects the chyle, with the fluids proceeding from the black-coloured blood, converting both the former and the latter into red blood, and afterwards into a fluid which

becomes capable, through the assimilating functions, of developing the organs, and of repairing the waste of the body ; the same respiration elevates, as we have said, the temperature of the blood, and proportions its component parts. Now, all these important operations of the respiration clearly show how close and intimate are the relations which unite with the circulation of the blood, the exercise of that function, upon which depend, at one and the same time, the improvement of the blood, and the course of its circulation.

It would therefore be certainly most strange to suppose, that in the presence of the different affections of the lungs, the relations which preserve their functions in an intimate and direct correspondence with the circulation of the blood, that these relations, I say, should not be proportionably altered, and capable of communicating the effects of their alterations to the whole system of the circulation of the blood, and, consequently, to the arteries and the pulse, which form a part of it : whether the affections of the lungs be trifling or serious, acute or chronic, they must all in proportion produce a change in the functions of that organ. Now the functions of the aereous organ are of three kinds ; mechanical, chemical and

vital. All of these, when out of order, accelerated, slackened or suspended, must necessarily change, accelerate, slacken or suspend the powers of the heart, which, as the centre and prime mover of the circulation of the blood, must communicate the effects to the whole circulatory system, and consequently to the arteries and to the pulse.

For, admitting, for a single instant, that the blood does not circulate freely in the pulmonary vessels, on account of some obstacle or obstruction, which takes place in the presence of tubercles or vomicae in pulmonary phthisis, or that the mechanical phenomena of respiration are slackened or interrupted in any manner; or that the blood itself does not receive a sufficiency of vital particles, so necessary to the preservation of life; in all these cases, the left ventricle of the heart and the arteries, which are neither sufficiently stimulated nor set in action by the natural stimulus of the red blood, and by the action of its vital particles, cannot but communicate, with the alteration of their functions, the impression of the pulmonary affections to the whole system of the circulation of the blood, and therefore to the pulse, since the heart and the arteries, in the healthy state, receive from

the functions of the lungs the elements of their strength, energy, and preservation. In fact, the asphyxia, or apparent death, which is the consequence of the want of respirable, oxygenated or vital air, is an evident proof of the direct influence which the mechanical, chemical and vital phenomena of respiration exercise over the contractions of the heart and arteries, which contractions, in the state of asphyxia, are, as is well known, extremely languid and slow, if not entirely interrupted or suspended. Hunter's experiment is in direct corroboration of this truth. This celebrated anatomist opened the breast of a living dog, removing the sternum and the cartilages, and cutting through the pericardium; then, in order to examine more closely the motions of the heart, he adapted for that purpose to the trachea, or *aspera arteria*, a kind of bellows, formed to resemble as closely as possible the mechanism of the inspiration of the lungs: by this means he observed that the contractions of the auricles of the heart were difficult and slow, so that they did not completely empty themselves of blood, and that the ventricles were soft and compressible in the diastole, whilst on the contrary they were hard in the systole; thus he says, the natural volume of the

heart was doubly increased when it was about to finish its action, so much did its ventricles dilate themselves at that moment. But what is most essential to know is, that when he suspended the use of the bellows, and the respiration became interrupted, the heart instantly ceased acting.

“Les médecins,” says the physiologist Dumas, upon this subject, “ n’ignorent pas combien la
 “ lésion profonde des organes pulmonaires al-
 “ tère et dérange le mouvement ordinaire de
 “ la circulation. La petitesse et la fréquence du
 “ pouls, la marche irrégulière de la fièvre, la ré-
 “ paration inégale de la chaleur, tout annonce
 “ que les fonctions du système vasculaire sont
 “ interverties, et que la marche du sang de-
 “ venue lente, pénible, déroge à ses lois ac-
 “ coutumées. Les défaillances, les syncopes,
 “ l’interruption momentanée des mouvemens
 “ du cœur, l’affaiblissement extrême de l’ac-
 “ tion artérielle et de la circulation, précèdent
 “ presque toujours la mort complète des in-
 “ dividus qui succombent à la destruction suc-
 “ cessive, c’est à dire, la mort partielle des
 “ poumons.” *

From hence we infer, that the lungs affected by any disorder whatsoever, cannot regularly

* See Dumas Op. cit. Tom. ii. p. 362 and 363.

elaborate the blood ; and the blood which is not well elaborated cannot, in its turn, stimulate and set in action, as it should do, the left ventricle and the arteries ; and hence proceed the various altered and disordered motions of the circulation of the blood, to which must be referred the alterations and inequalities of the pulse, which, as we shall see, indicate the presence of the different affections of the lungs, together with their degree of severity or slightness.

This, therefore, is the proper place to remark, that the state of the vital powers also varies, according to the manner in which the patient breathes ; or, what is the same thing, according to the degree of coloration of the blood, which depends upon the state of the lungs. Hence every thing concurs in showing the reason wherefore the affections of the aereous organ influence the circulation of the blood, in such a manner, as to show, to a certain degree, how it happens that these are propagated, so to speak, under the form of so many morbid impressions, from the lungs, the centre of these affections, to the heart and arteries, and consequently to the pulse, which, as we shall see, indicates their existence.

Thus, besides the above-mentioned relations,

which unite the circulation of the blood with the respiration, there is also to be observed; 1st, the proximity of the lungs to the heart, which are so near together, as to make it appear that nature had wished to make but one and the same organ of both; 2dly, that the lungs appear to be nothing else than a collection of vessels, since, in the last analysis, they exhibit themselves under the form of an organ of a vascular nature, which caused Bichat to say, "*Ces organes,*" speaking of the lungs, "*seront donc presque entièrement vasculaires.*"* And under this double relation of proximity to the heart, and of vascular structure, the lungs sympathize in such a manner with the circulation of the blood, as to enable us to infer from the alterations of the latter the affections of the former.

In the second place, the relations present themselves which unite the system of the circulation of the blood with the brain, and explain the cause of the different morbid pulses, arising from diseases of the cerebral organ, which certainly affect the harmony and order of their relations. It is true, that the brain, as the centre of the animal life, cannot have a direct and immediate communication with the

* See Bichat, *An. descrip.* Tom. iv. p. 70.

heart, which is the focus of the organic life ; but it is not less true, that each communicates with the other mediately ; that is, by means of the lungs. In fact, when the intercostal muscles do not contract, and when the diaphragm does not become depressed, the dilatation of the thorax cannot take place ; the act of inspiration consequently becomes defective, and the circulation, together with the exercise of all the other functions, is arrested. “ Si le double
 “ mouvement de dilatation et de resserrement
 “ du thorax, par lequel l’air s’introduit dans
 “ l’intérieur des poumons, et en est expulsé
 “ après un certain séjour ; si ce double mouve-
 “ ment,” says Bichat, “ cesse un instant, le
 “ sang cesse d’être élaboré par l’air, et la
 “ circulation s’arrête bientôt.”

Now it is well known, that the nerves of the brain are those which influence the contractions of the intercostal muscles and of the diaphragm ; and that the latter and the former are so many direct agents in the exercise of the respiration.

Cruikshank having cut the spinal marrow of a living dog through the last cervical and the first dorsal vertebræ, destroyed in this manner the communication of the intercostal nerves with the brain, and the

action of the muscles similarly named to the nerves ceased immediately afterwards. And if at the same time the phrenic nerves are cut at the point where they originate, the diaphragm also ceases to act, lowers itself, and falls into a perfect paralysis. Both experiments prove, therefore, clearly, that the mechanical phenomena of respiration are intimately united with the brain, because they are influenced and set in action by its nerves.

Admitting, therefore, that the mechanical phenomena of the respiration are altered or slackened by some cause or disease existing in the brain; must it not follow from this hypothesis that its chemical phenomena must be equally altered and changed, as being dependent upon them? But the blood which is not sufficiently red, nor well elaborated, certainly does not possess the necessary strength, either to excite, as necessity requires, the left ventricle of the heart, or to elevate, at need, its force, already languid, and much less to revive the vital strength of the body; hence proceed the anomalies and the alterations of the contractions of the heart and arteries, and consequently those of the circulation of the blood and the pulse, which immediately depend upon them.

The lungs are, therefore, an intermediate organ between the brain (upon which depend the mechanical phenomena of the respiration, as these are exercised by means of the influence of the intercostal and phrenic nerves) and the heart, to which the lungs administer, through the medium of their chemical phenomena, the elements of its power and energy: hence it is clear, that the respiration exercised by the lungs is a mixed function, inasmuch as it participates of the animal and the organic life. It is, therefore, not without reason, that those animals, whose respiratory apparatus is more complicated and perfect, have the brain proportionably more voluminous, and the heart more bulky, and *vice versa*. Such at least is found to be the case with birds and mammalia, in which the aereous organ, the brain, and the heart, are proportionably developed and complete; whereas the same organs are found to be wanting or incomplete in reptiles and fishes, on account of the imperfection and simplicity of their respiratory organs. In other words, the brain, and, through it, its nerves, have an influence upon the exercise of the mechanical phenomena of the respiration, and therefore upon the heart, and the system of the circulation of the

blood, whose exercise directly depends upon the phenomena of the respiration.

But if the brain does not directly influence the heart, at least the function of the latter has a direct influence upon the mechanism of the operations of the former ; and this suffices to show that both are in relation with each other. In fact, whilst the heart revives and elevates the sphere of activity of the brain with its energetic vibrations, it continually keeps on furnishing vital particles to that organ by means of the carotid and vertebral arteries. At the moment that the left ventricle contracts itself, it forcibly impels the red blood into the aorta, and consequently into its branches, the carotid and vertebral arteries : by this means the red blood rapidly approaches the substance of the brain, and communicates to it a certain alternate motion of elevation and depression or lowering, incessantly exhibited by the cerebral organ in the state of life. After this we perceive the other effect of the influence of the heart upon the brain, which originates precisely from the distribution of the said nutritive particles, which are conveyed there with the red blood, by means of the above-mentioned carotid and vertebral arteries ; by which the reason

will be understood, why the contractions of the heart directly reanimate the vital powers and the operations of the brain.

A still more evident proof of what we have asserted, results from the experiment, made by cutting off a part of a living animal's cranium, and interrupting at will the course of the blood, whether in the carotid or the vertebral arteries, or in both at the same time: when the course of the blood is interrupted in either of these arteries, the brain then becomes elevated almost by half, and the animal appears more or less oppressed and stupified; but when the course of the blood is intercepted in all these arteries at the same time, the brain then becomes depressed, and the animal dies: thus, the more perfect the animal subjected to this experiment, the quicker and more sensible is the result.

Hence, if there are direct and indirect relations between the heart and the brain, and the brain and the heart; I ask, why the alterations of their relations in the presence of diseases of the brain, should not be transferred to the heart, to the system of the circulation of the blood, and consequently to the pulse? Otherwise we should be at a loss to explain why in hydrocephalus, which is a disease of the

brain, the pulse is at the commencement quick, and afterwards somewhat rare, and then intermittent; and why it is hard, tense, vibrating and vehement, in the presence of phrenitis or inflammation of the brain ; thus, in both diseases, the pulse never fails to exhibit itself under the character of a capital pulse, which we shall proceed to examine in the second part of this treatise, under the head of Organic Pulses.

ART. XIV.

CONTINUATION OF THE SAME RESEARCHES UPON
THE RELATIONS WHICH UNITE THE CIRCU-
LATION OF THE BLOOD WITH ALL THE
OTHER FUNCTIONS OF INTERNAL,
ORGANIC OR VEGETATIVE LIFE.

IN the third place, the relations by which nature connects the circulation of the blood, and the nourishment of the different organs of man, appear to be not less intimate and close. The nutrition which is effected by means of the circulation of the blood, and the organs of this function which receive new life and vigour from the former : both effects, certainly prodigious, arise precisely from their intimate connexion and reciprocal dependence.

In this luminous truth, all the most distinguished physiologists of Europe concur. “ L'action des vaisseaux et le mouvement
“ du sang,” says, among others, the learned Dumas, “ portent les sucs nourri-
“ ciers à toutes les parties : et si les vices
“ de la circulation, la perte de quelque
“ branche considérable de veines ou d'ar-
“ tères empêche cette distribution, l'organe
“ où elle ne peut avoir lieu, ne prenant
“ plus sa nourriture, se flétrit, se consume

“ et meurt.”* So closely united together are the circulation of the blood, the nutrition, and the well-being of the different parts of the body.

Amongst the other effects of nutrition, the most sensible to every eye, is that of the developement of the various organs, and different parts of which man is composed ; an evident proof of which is given in the remarkable increase of the fœtus. This, from the smallest embryo, or globe scarcely perceptible, such as it is found in the uterus after the first days of conception, becomes so enlarged and developed, as to be incapable of remaining or being supported there at the end generally of nine months ; upon being freed from the womb, the body of this new creature recommences its progressive increase ; and from a tender infant it succeeds gradually in acquiring the dimensions, tone and strength which characterize the adult : now it must be observed, that all these phenomena or successive advances of the body of the fœtus, and afterwards of the child, correspond with, and are proportioned to the degree of activity of the arterial system. By examining, as is done, the abortions of every size and bulk, which

* Dumas, *Op. cit.* Tom. ii. *p.* 285.

are to be met with in different periods of pregnancy, a favourable opportunity is obtained of observing the successive advances, which the body of the foetus *in utero* makes at the expense of the juices of the mother, and which generally correspond with the value of her arterial system.

In the absence of such speaking examples of the developement and increase of the body, we may have recourse to other well-known means; of these the most useful is that, of examining gradually the developement of the chicken in the egg. The learned professor Scarpa, who has had the patience to trace the commencement and the gradual developement of the chicken from the first days of incubation till its complete increase, clearly shows in his treatise, *de penitiori ossium structura*, the progress of the process of ossification, which is effected by means of the phosphate of lime, which the arterial extremities successively and prodigiously deposit in the cellulous tissue of the bones, whose threads, as yet cartilaginous, become incrustated, and afterwards perfectly hardened.

The other wonderful effect also which arises from the nutrition, is relative to the daily reparation of those solid and fluid particles,

which escape in various ways from the bodies of warm-blooded animals, and which are replaced by other like particles: now these latter are the production of fresh aliments digested, modified and transformed into so many chylous or even organic molecules by means of the assimilatory functions, according to the researches and experiments made by Messrs. Leuret and Lesseigne.

The motions of the organs, their wear and tear, the contractions of the heart, arteries, muscles, and similar parts; the passions of every kind, the air, food, watching . . . in short all the internal and external stimulants so necessary to the preservation of life, are precisely those which occasion the decay of the vital powers, a decay which exactly corresponds to the sum of the solid and fluid particles, involuntarily dissipated by man at every moment of his existence. These continued and daily losses are providently supplied, by nature, with the addition of those substances, which result from a series of decompositions and new compositions which are actually effected in the great laboratory of the human body.

That such an interchange, so to speak, of the exit and entrance of solid and fluid par-

ticles, does actually take place in the human body during the exercise of life, is indisputably proved by the well-known experiment of making an animal eat madder-root; for, the use of this substance in course of time spreads over the bones of the animal a red tint, a colour which always disappears in a few days after the use of the root has been suspended. And if such an interchange of exit and entrance of solid and fluid particles takes place in the hard parts of the human body, how much more should not this phenomenon occur in the organs, vessels, membranes, and the other soft parts? both the effects of nutrition are therefore, as we have said, most evident to the senses, we mean, the developement of man's organs, and the reparation of his daily losses, which show the renovation of which the human body is capable, and which should fix the attention of physicians in the cure of certain humoral diseases. “*La substance du corps animal,*” says Dumas, “*est donc sans cesse recomposée, reproduite, renouvelée, et les actes de composition répondent exactement à ceux par lesquels elle se décompose.*”*

* Dumas, *Op. cit.* Tom. ii. p. 271.

The doubt certainly is not respecting the effects of the nutrition, because these are, as we have said, most evident to the senses ; but it is the deep obscurity which hangs over the mechanism employed by nature to develop the organs and repair the waste of the body, it is this obscurity which humiliates and astonishes every mind. To say that nutrition is a secretion, and that the osseous, tendinous, cartilaginous, muscular, membranous, nervous, &c. fibres, are so many secretory organs of other smaller osseous, tendinous, muscular, nervous, &c. fibres, are fine words which explain nothing.

The nutrition, properly so called, which is confounded with the identification of the chyle and blood in a substance homogeneous to that which develops the organs and repairs the losses, is certainly different from the other function which physiologists call secretion ; which rather exercises its mechanism upon the effects of the nutrition ; its exercise is direct to the preparation of some, only, and not of all the animal humours, since the majority of these exist ready prepared in the mass of the blood ; nor is the mechanism of secretion so complicated as that of nutrition, which has for its object to assimilate to the nature of the vari-

ous and different organs of man the nutritive molecules of the aliments, likened by Lorry to a mucous substance, but which Cullen makes to consist in a saccharine matter, and Hallé, in an hydro-carbonate.

This, however, is not the place, to investigate the great difference existing between nutrition and secretion, much less how nature organizes the nutritive substance, which is transformed into so many different fibres, and how it operates in order that the organs may develop themselves and increase in size: the present object of our curiosity is to observe, how the laws which maintain the known effects of nutrition can point out any principles of the science of the pulse.

It is certain that the physical state of the organs of man, and the tone assumed by the functions which they exercise, are all of them proportioned to the value, whatever it may be, of the effects of nutrition; for, when the produce of this function does not correspond to the double effect of regularly developing the organs of man, and of repairing, as necessity requires, the daily waste; in this double case there necessarily results from it the decay of the vital powers, to which must be referred that slowness, or depressed tone, with which all

the functions of life are then performed, a circumstance which is verified beyond all doubt in the abstinence which invalids generally observe in the course of their illness, for which due allowance must be made when examining the pulse; for the slackened course of the nutrition weakens in its turn the contractions of the heart and arteries, and by that retards the course of the circulation of the blood, from which is immediately derived the deterioration of the pulse, a deterioration which is connected with the altered state of the nutrition, and which exaggerates the alterations of the pulse in a state of disease. In the period of fasting, the parts of the body cease to appropriate to themselves a fresh nutritious fluid from which they obtain the principle of their natural strength and energy, and this produces the other disturbance in the circulation of the blood, which has a direct influence upon the state of the pulse.

And when it happens on the contrary, that the produce of the nutrition is too exuberant, from either of the above-mentioned effects; then, the circulation of the blood instead of performing its course slowly, as in the first case, assumes at the commencement a tone of violence; for, the blood which obeys the energy

of the contractions of the heart and arteries, runs there with such rapidity and impetus as to exhibit in like cases the full, quick and strong pulse of man, in the sthenic state. But after some lapse of time, the physical state of the body changes its aspect, although the cause itself does not cease to act and even with greater force. In fact, as soon as the arteries which become more and more charged with blood, by reason of new nutritive particles, do not, from this state of fulness, allow space sufficient for the sanguineous waves to proceed freely in their course; the stimulus of the blood becomes incompatible with the excitability of the heart and arteries, the energy of which at length yields to the oppressive mass of the blood, made heavy by so many nutritive particles, and the function of the circulation of the blood falls into a certain degree of atony or slowness, although it falls by an excess of organic molecules. Such is the case with habitual drunkards and gluttons, who, from the abuse of liquors and food, in the end become enervated, and are often afflicted with vertigo, or struck with apoplexy, which is caused by the over-fulness of the blood-vessels. This altered state of nutrition must also be taken into account in the examination of the

pulse, in a state of disease ; since, whilst it sensibly alters the state of the pulse, this alteration does not in the least depend upon the character of the disease.

Now what is most deserving of notice is, that when the body of gluttons is arrived at a certain degree of fatness, their organs then commence, by a law of provident nature, to reject the excess of the nutritive particles, which there present themselves, and this, because they no longer feel the necessity of retaining them as before. The organs, in order to reject the excess or the exuberance of the nutritive particles, employ the reaction which they display against the impulsive force of the blood and arteries, which transport them there for that purpose ; and if it were not so, that the organs resisted, by rejecting them ; there would arise the disorder that all the organs would develop themselves rapidly, or acquire an extraordinary size, which is repugnant to the laws of the regular increase of the bodies of animals ; and when nature alienates herself from her laws, for some physical derangement, there then results the morbose state, or the premature if not sudden death of the animal, arising from the superabundance of blood, which physicians call *plethora*.

And it is precisely the reaction which the organs exert upon the arterial extremities, which bring there the nutritive materials, and with which the organs themselves are intimately united; it is precisely this reaction, which alters the function of the circulation of the blood, and consequently the beatings of the pulse, which cannot but make known to the medical observer, by its alterations, the state, whatever it may be, of every organ and function of man, in the double state of *sthenia* and *asthenia*.

The arteries, such as we find them disposed and distributed through the human machine, constitute an organized system, which system must of course be both sensible and excitable. In consequence of this vital quality, it cannot but feel the effect communicated to it by the reaction of the various organs. Hence, as often as the various reactions, which the different organs produce upon the arterial extremities that supply them with the nutritive particles, are altered; the reactions so altered must act in a different manner upon the excitability of the arteries; disturb the regular order of their oscillations, and by means of the new mode of beating of the arteries, and of the pulse, we are enabled to ascer-

tain, the altered reactions of the organs, and by a succession of observations the cause of those alterations. There can therefore be no longer any doubt upon the sensibility or excitability of the arterial system, having demonstrated its existence in our examination of the physico-vital powers of the heart and arteries.

Hence, inasmuch as the organs of man are nourished, and live at the expense of the red blood, by which they receive the nutritive particles which promote their developement, and fill up the void and the daily waste of the body ; inasmuch as the arteries, which distribute themselves in a thousand ways through their fabric and structure, are those which administer the nutritive particles and are intimately united with the organs themselves ; for all these reasons, we feel ourselves authorized to conclude that the alterations of the organic functions must transfer themselves necessarily under the aspect of distinct impressions, from their seat, or from the organs affected to the sense of the educated touch of the observer, through the medium of the arterial system ; the more so as the arteries are the same as so many conductors which spread through the organs the elements of their

strength and energy; which participate in their mode of being; which form part of their structure; which place them in a reciprocal dependence with the heart, and divide with the organs themselves all the acts, modifications, alterations, and all the other accidents of their life.

In support of this principle come, in the last place, the proofs which result from the examination of the relations, which place in a reciprocal dependence the different secretions with the circulation of the blood, and therefore with the beatings of the pulse. All the animal humours undoubtedly come from the blood; with the sole difference, that of these some are found ready prepared: such are the gelatinous, albuminous, serous, lymphatic and aqueous humours; these transude across the corresponding serous membranes, the glands of the skin, and other like parts; where the other humours require to be more or less elaborated by particular organs. In this order are the mucous, salival, bronchial, gastric, pancreatic, bilious, urinous, spermatic, lacteal, and oleous humours, the preparation of which is owing to a succession of new combinations, which manifest themselves in the conglomerate glands, in the parenchyma of certain viscera, in the mu-

cous membranes, in the cellular tissue, and so on.

The animal humours have been subjected to various classifications, whilst nature indicates one only, which results from the chemical analysis of different humours, or from the examination of the structure of the various organs which prepare them. Besides, it is sufficient here for us to set off from the principle known and sanctioned by the most enlightened physiologists, that all the above-mentioned animal humours are separated from the blood by means of the arterial extremities which form a part of the inner tissue of the secretory organs. How the arterial extremities in the said organs do this, is another of nature's secrets, into which it is not important here to inquire.

What is most interesting for us to know, at present, is, that the structure or peculiar disposition of the tissue of the different secretory organs, directly influences the various characters of the humours which they elaborate and prepare; otherwise, it would be impossible to say why nature has constructed the secretory organs in so many various ways and different forms; and, as the particular disposition which the arteries take, in distributing

themselves so differently in the various organs, does not appear to be an object of indifference; the interest, therefore, which the arteries assume in the different preparations of the animal humours, cannot be small. To this phenomenon, in fact, contribute, not less, the greater or less number of the arterial ramifications, and the mode in which they display themselves, than their diameter, which varies wonderfully. “Le nombre et la grandeur des vaisseaux,” says Dumas, “établissent une suite de proportions diverses entre la consistance des parties du sang et la capacité de l’organe qu’il doit pénétrer. Si leur diamètre est fort petit, ils n’admettront que les parties les plus fluides du sang, ils rejetteront les parties lentes et visqueuses. Or, comme le diamètre des canaux peut varier à l’infini, il doit résulter des proportions infiniment variables entre eux et le sang, et par conséquent une source inépuisable de différences dans le produit des organes sécrétoires.”*

In short, every thing combines to prove that the arteries conform and adapt themselves to the intentions, so to speak, of the different se-

* Dumas, Op. cit. Tom. ii. p. 25.

cretory organs, in order to concur, in this manner, in the preparation of the different animal humours : in other words, the exercise of the various secretions belongs as well to the different secretory organs, as to the arterial extremities, which constitute the most important part of them, and are, for reasons already shown, strictly united with them.

Thus, in our opinion, the work of the secretory organs falls almost wholly, in the last analysis, upon the mechanism of the arteries, and consequently upon the exercise of the circulation of the blood. Ruysch, Albinus, Haller, Lobstein, and many other distinguished anatomists, also agree that the vascular structure predominates in the secretory organs.

Thus, by way of example, it is the innumerable arterial extremities which distribute themselves throughout the whole external covering of the body which there constitute the secretory organ the matter of transpiration. When once, therefore, the function of transpiration has been altered by any cause or disease whatsoever, should not that alteration extend itself throughout the whole arterial system, and reach the radial artery or the pulse? A proof of this kind in fact presents itself in the observation of the *cutaneous, wavy,*

or *inciduous* pulse of Solano, which announces, as we shall see, the critical sweat, and arises from the movements or efforts which nature concentrates in the arterial extremities of the external covering of the body.

In like manner the arterial extremities which distribute themselves in the internal superficies of the villous membrane of the stomach, are those which separate from the red blood the elementary principles of the gastric juice. And why not then admit that the diseases of this organ are capable of altering the functions of its capillary arteries, and of communicating by this means the morbose impression to the rest of the arterial system? Or, in other terms, the reaction of the vital power of the stomach, in the state of disease, must, of course, alter the exercise of the function of the capillary arteries of the villous membrane; and it is this alteration, which suddenly communicates itself to the coronary and gastro-epiploic arteries, and thence to all the arterial system, which receives the impression precisely as observed upon the radial artery. Why not then acknowledge, from so intimate a connexion between the arterial system and the vital power of the stomach, the sufficient reason of

the pulse, which indicates the presence of the diseases of the stomach?

Proceeding on in this manner, it will be seen, that the extremities of the renal arteries which detach themselves from the branches of the emulgent artery, exhibit in the kidneys the form of another secretory organ of the urinary materials. The introduction (in no wise difficult) of water, mercury and wax across the tissue of the kidneys, and the rapidity with which these injected substances pass from the renal arteries to the conduits or tubes, and from these to the renal pelvis, clearly shows how much the vascular structure predominates in the kidneys. The renal arteries, being thus fashioned in the form of a secretory organ, separate from the blood the urine, which there exists in miniature; thence, this excrementitious liquor passes into the tubular substance, where it acquires its proper chemical character, and from thence into the renal pelvis, and then into the bladder by means of the ureters. Now, it would be absurd to maintain that the kidneys, and by these the ramifications of the renal arteries, which compose, as we have said, the most important part of them should not, in the state of nephritis or of any other acute or chronic disorder, communicate the effect of

their alteration, whatever it be, to the renal arteries, the emulgent artery, and thence to all the rest of the arterial system, which is excitable, identical and uniform in all its parts. Then must not the radial, temporal and carotid arteries, which form part of the arterial system, by their altered beatings necessarily inform the touch of the physician, who is well versed in this kind of knowledge? Such is the principle upon which is supported the sufficient reason of the renal pulse, of which we shall speak in its place.

And by continually following the light of anatomy and physiology in the examination of all the other secretory organs; such as, the liver, the pancreas, the testicles, &c., in which the action of the arteries always predominates in the secretion of the principles of the bile, of the pancreatic juice, of the seminal liquor, &c., by following this light, we arrive at the conclusion, that the doctrine of the pulse which is founded upon the bases furnished by the science of man and practical observation, is no longer a mere play of the imagination, or deprived of justness and foundation.

In confirmation of this truth may be indeed adduced the morbose impressions, which communicate the different affections of the various

secretory organs to the blood-vessels which are ramified in them, and constitute the part which has the greatest influence upon the character of their functions. Thus, by a cursory examination of the liver, we shall see that the small glands which compose the real substance of this organ, and which are called *pedicilli*, are merely, in the last analysis, ramifications of the vena porta, which performs the office of an artery. The *pedicilli*, and not the lymphatic vessels, as some think, separate from the blood, contained by them, the principles of bile, and discharge them into the biliary pores, which consist of other small vessels, from which the bile issues better elaborated; thus prepared the bile passes into the hepatic duct, which itself results from the union of the just-mentioned biliary pores. Hence it follows that the proper substance (so to say) of the liver, is the same as a collection of vessels.

Must not the hepatitis, therefore, or any other affection of the liver necessarily put in disorder the function of the ramifications of the vena porta, in which these affections are received? And is it not natural that the effect of the disease should extend itself from the *pedicilli* to the whole system of the circulation of the blood? Thus it comes to pass that the

pulse discovers to the touch and the mind of the physician the presence of the affections, to which the liver is subject; and it is for this reason that the pulse which indicates and accompanies them is called *hepatic*.

Whether, therefore, according to Malpighi, the structure of the liver consists in an assemblage of small grains, perforated with an internal cavity, united by the cellular tissue, and contained in a membrane over which are spread numberless retiform blood-vessels; whether the whole structure of this organ is reduced to a knot of very minute vessels, united and entwined in the form of glands, as is the opinion of Ruysch; however this may be, it is certain, that all the parts of which the liver is composed correspond and communicate with each other. To this conclusion we are led, at least, by an experiment which may be repeated at pleasure. “On a fait,” says Dumas, “des
“ expériences qui démontrent la correspon-
“ dance et la communication qu’il y a entre
“ les dernières ramifications de la veine porte
“ et les radicules des conduits biliaires, entre
“ ceux-ci et les extrémités des divisions de
“ l’artère hépatique, entre ces dernières et la
“ terminaison de la veine porte, entre les
“ conduits biliaires, les veines hépatiques et

“ la veine cave, puisque l'air et les fluides
“ injectés passent facilement d'une de ces
“ parties à l'autre.”*

From the same anatomical dispositions which are found in the structure of the pancreas, and also of the testicles, arises also the reason, why the diseases of these organs communicate their effects, that is those of the pancreas to the pancreatic and the splenic arteries, and so on; and those of the testicles first to the spermatic artery, its ramifications being those which constitute the true substance of the testicles, and afterwards to the aorta, and to all the arterial system; thus the alterations which proceed from the affections of these and other secretory organs to the arterial system, arrive by this means to the touch of the physician, with such a force that he can nearly judge the degree of irritation, orgasm, or excitement in which the organs are found to be when affected by hypersthenical diseases. The blood which then runs there with much velocity on account of the morbose stimulus, exacerbates the functions, and produces there an increase of irritation, so sensible that it would be a complete

* See Dumas, *Op. cit.* Tom. ii. p. 78.

paradox to believe, that the whole arterial system, and consequently the pulse which depends upon it, should not participate in it.

From all that has been hitherto said we infer that the means which it is necessary for the physician to employ in order to confer with nature, for the purpose of determining the character and the centre of every organic affection, and of immediately hitting upon the cardinal point of their indication: that such a means, we say, differs not from that of studying, by an attentive examination of the pulse, the variations and changes of the circulation of the blood, as that function which is intimately united with all the other partial actions, or functions of life.

ART. XV.

ORGANICAL LAWS WHICH FACILITATE THE GENERAL
KNOWLEDGE OF VARIOUS MORBOSE PULSES.

ALL physiologists know that the organs of man enjoy a partial life, and that they are generally considered as so many small beings entirely different one from another. Not only does nature give an example of this in the family of the *polypi*, which make common life in the corals, in the madrepores, and lithophytes, whilst every little animal is a distinct being; but we also find unequivocal proofs of this in the examination of the organs of man. In fact, when we find that the eyes distinguish external objects, without at the same time being sensible of the action of sonorous bodies; that the organ of hearing receives the impression of sounds, while it is incapable of feeling the action of savoury bodies; that the palate is sensible of the taste of those bodies, whilst it rejects the action of odorous substances, or manifests indifference to them; that the Schneiderian membrane, and through it the organ of the smell, obeys the stimulus of odours, whilst it is not allowed to distinguish the smoothness or roughness of natural bodies;

that the touch feels and distinguishes the action of these, whilst it is not formed to receive the impression of the light, of sonorous bodies, &c. ; all the above facts are sufficient to convince us that every sensory organ has, in fact, a partial and distinct life, a particular mode of feeling, and we will even say with Baillou, its wants, its uses, its habits, and consequently a character peculiar to itself, which distinguishes it from the other sensory organs.

Nor is it to be supposed that such an order of things is limited to the sensory organs alone, because we equally observe that the elementary principles of the bile which are contained in the blood, act upon the excitability of the liver, whilst they do not produce the least impression of stimulus upon the sensibility of the lungs ; that the atmospheric air acts efficaciously upon the tissue of the lungs, whilst it is incapable of exciting the sensibility of the stomach ; that the tonicity of the heart and arteries obeys the action of the blood, whilst these latter remain indifferent to the stimulus of the gastric juice, to which the excitability of the stomach is obedient : the same may be observed of the pancreas, the kidneys, the testicles, and of every other internal organ, the excitability of which always sympathizes

with the stimulus which is conformable to its individual and specific organic disposition.

So true is this, that some fluids pass round certain apertures without entering them, and this because the sensibility of these apertures does not sympathize with, or is not analogous to the character of those fluids. In like manner the *aspera arteria* or trachea, whilst it gives a free passage to the atmospheric air, rejects by its convulsive efforts every other body, whether fluid or solid, which happens to arrive there. For the same reason the blood does not penetrate into the thoracic duct, although it is furnished with a valve, which is sometimes insufficient to oppose the ingress of the blood. So likewise the urethra drives back the urine in the convulsion of coition.

Now, this particular mode of feeling, belonging to the various organs of man, should not, on the other hand, induce us to suppose erroneously, that excitability has as many different characters as there are organs which are furnished with it, and much less that the nerves from which they repeat it have a different character or nature. Both these errors will be avoided, by considering that all the sensations excited in us by the various stimuli, are reduced to those of the touch. Excitability

is certainly the faculty which the organs have of feeling, and in fact they all do feel, although each in a manner peculiar to itself. But this their specific manner of feeling, which does not on that account deprive them of feeling either stimulus, depends rather upon the diversity of their construction, and to the variously-modified forms and fashion, with which the nerves exhibit themselves in the tissue of various organs ; it is precisely because the eye is not constructed like the organ of hearing, and that the acoustic nerve is disposed and placed in the latter in a different manner to that in which the optic nerve is placed in the former organ, that the first is capable of feeling the action of the light, and the second that of sounds.

This is then the reason by which the eye distinguishes objects, the ear sounds, the smell odours, the palate food, and the touch the temperature and the smoothness or roughness of bodies. The same can also be said of the internal organs ; for, if the excitability of the kidneys obeys the action of the urinary elements, and that of the heart the stimulus of the blood, it so happens because the construction of the one is not similar to the tissue of the other ; but it does not therefore follow,

that the heart and the kidneys have two different excitabilities, because the former obeys the stimulus of the blood, and the latter that of the urine.

Now it is in this arrangement of things that we discover the cause of the various pulses ; since, admitting the principle already acknowledged as true by all physiologists ancient and modern ; viz., that every organ has a partial life, and a mode of feeling peculiar to itself ; it cannot but be likewise certain that every organ must, when in a state of affection, receive from that affection a morbose impression, which, in order to be of a character conformable to the distinct mode of feeling of the affected organ, cannot but exhibit itself under a form or character different from that of any other organ whatsoever similarly affected. The sphere of activity of any organ has all the influence upon the form, character, and therefore upon the severity or lightness of the disease, by which that organ is affected. Thus, it is a matter of fact, that the various organs are not even all affected by diseases of the same kind, so much does the sphere of activity of the different organs of man influences their developement ; and, when the contrary happens, as is the case in inflammations, which can at-

tack nearly all the organs without distinction, in such a case the modifications to which inflammatory disorders of the various organs are subjected, by reason of their particular mode of feeling, will be sufficient to distinguish their form and their various degree of intensity.

It is then the different organization of the parts, and consequently their particular mode of feeling, which gives to the affections of various organs a distinct form, and to the pulse as many characters, as the various organs affected are numerous. In proof of what we here advance, may also be adduced the authority of John Hunter; who, treating of inflammation, expresses himself as follows: "When we consider that the same kind of inflammation in every part of the body will not produce the same kind of pulse, but very different kinds, not according to the inflammation, but according to the nature of the parts inflamed, and those other parts also not visible, we lose at once the criterion of pulse as a guide."*

We have said that the various organs are not all indifferently subjected to the affections of the same kind, inflammation excepted, and we

* See Hunter's Treatise on Inflammation, p. 117.

find the proof of this in practical observation; for, we daily see that the syphilis attacks the glandular and lymphatic systems, where it usually remains, whilst it leaves free the other parts of the body; that the pulmonary phthisis invests the tissue of the aereous organ, whilst it spares the other organs; that rheumatism invades the muscular system and the articulations, whilst the other systems are free from it; so likewise epilepsy is confined to the nervous system; while the tetters are limited to the superficies of the body, and so on; and although the different diseases may in time extend themselves from one organ or system to another, by means of the relations by which the various organs and systems are united by nature; it nevertheless always remains certain, that it is the different construction of the organs, and their peculiar mode of feeling, which imparts to diseases the form, character, and degree of intensity.

Hence, in proportion as the degree of sensibility of an organ is more or less elevated, so in proportion should be greater or less the degree of intensity of its affections, which, in order to be different from that of any other organ differently constructed, must of necessity alter in a very distinct manner the circu-

lation of the blood, and consequently the pulse which depends upon it. Besides, every organic action which is altered by the presence of a local disease, must itself change in its turn the circulation of the blood, and consequently the pulse, in a particular and distinct manner, as soon as every organic affection produces in the motion of the arteries of the viscus, or organ attacked, a change, which precisely because it corresponds to its mode of feeling, or the degree of its vitality, must certainly be different from the affections of any other organ.

This is the reason why diseases of the nervous system sensibly alter the circulation of the blood, and the beatings of the pulse; whilst the affections of the glandular and lymphatic systems scarcely disturb their regularity. In general, the more sensible an organ is, and the more solid and consistent its structure, the greater should be the vivacity, hardness, tension, and depth of the beatings of the pulse which indicates its affections, and *vice versa*.

By following, in fact, the same researches in the affections of the internal organs, we shall clearly perceive the general law, that to the various degree of sensibility or vital ac-

tivity to which the different organs are elevated by nature, correspond exactly the various disorders by which they are affected, their degree of intensity, and with that the various alterations of the circulation of the blood and of the pulse. Thus, abstraction made of the various symptoms, and of the different site of the pain, which distinguish the pulmonia from the splenitis, we also find in the pulse's various mode of beating another well-marked character, by which we may distinguish one inflammation from the other; because the elevated degree of sensibility or vital activity which belongs to the lungs, causes, when it is excited by the presence of the pulmonia, a very great alteration in the circulation of the blood, and this necessarily makes the alteration of the pulse strong and sensible; whilst in the splenitis it is very little if at all changed, because the spleen, which is affected in the second case, is much less excitable than the lungs. "*Partes magis sensatæ,*" says Actuarius, "*pulsus ob dolorem commutant; quæ vero minus habent sensus, pro solius affectus ratione pulsum variant.*"*

* See Actuarius, de Arte Sphygmica.

All diseases, both external and internal, organic or general, all in proportion to the sphere of activity of the parts affected, or, which is the same thing, in proportion to the place they occupy, produce a revulsion or disorder, more or less sensible, in the system of the circulation of the blood, which system, by the relations of identity of structure, must of course directly communicate that disorder to the pulse, which forms part of it; and, for this evident reason, the pulse can no longer beat regularly, as it does in the natural state; and hence are derived the informations necessary for characterizing, prognosticating and curing the different diseases.

Thus, from what has been advanced in this article, it appears clear, that, in order to distinguish the different morbose pulses, it is of the first importance, in the present state of the science, to recall to the mind, when in the act of examining the pulse, the different degrees of sensibility, or of obtuse vitality of the different organs; since, by this is acquired the other power of determining the various degrees of strength, or of alteration of the beatings of the pulse, and what organ, viscus, system or part, is affected. Such is the goodness of Nature, who has permitted that

the various mode of existence or different degree of vital activity of the various organs should lead to the general knowledge and distinction of the different morbid pulses; and these indicate by their force and variations the viscera or organs which are affected: thus it may be said that they mutually conduce to the knowledge of each other.

The truth to be observed in the last place would be that of going into the comparison of the more sensible organs with those which are less so, and with those of obtuse vitality, if all physiologists did not know, that the degree of vital activity of an organ, viscus or of any part of the body, depends directly upon the number and calibre of the nerves and blood-vessels, which are there distributed. The nerves and blood-vessels, are in fact an approximative scale, as well of the degree of sensibility, or vital activity of the different parts of the human body, as of their degree of tendency to inflammation.

From this will be understood the reason why the bones, cartilages, ligaments, tendons and the cellular tissue which are scantily supplied with nerves and blood-vessels, with difficulty contract a state of inflammation, and operate but little or no alteration in the course

of the blood, and in the beatings of the pulse in a state of disease, and *vice versa*. “Aussi
“ remarque-t-on,” says Bichat, “que la vie
“ est bien plus active par-tout où les artères
“ sont très-multipliées, comme aux muscles, à
“ la peau, aux surfaces muqueuses, etc.; tandis
“ qu’au contraire ses phénomènes sont moins
“ forts et plus obscures dans les organes peu
“ vasculieux, comme dans les tendons, les car-
“ tilages, les os et les autres parties blan-
“ ches.”*

Besides the principles we have pointed out in this first volume, and which the science of the pulse has, as before observed, borrowed from anatomy and physiology; there are others also which it derives, as we shall see, from pathology and practical observation. The union of all these principles arranged and disposed in the best manner according to the nature of the materials supplying them, might certainly one day raise the science of the pulse to its proper rank. If nothing else, our successors will find in the exposition of the elementary principles from which we set out in order to proceed in the examination of diagnostic, organic, and critical pulses; if nothing else,

* See Bichat, An. gén. Tom. ii. p. 267.

we repeat, they will find reasons which will caution them to avoid the errors into which we may have been led, either by a deficiency or scarcity of ideas respecting the subject of the treatise, or from not having formed a right opinion upon the facts we are in possession of, or finally from our not having used words adequate to the importance of the subject.

END OF THE FIRST VOLUME.

